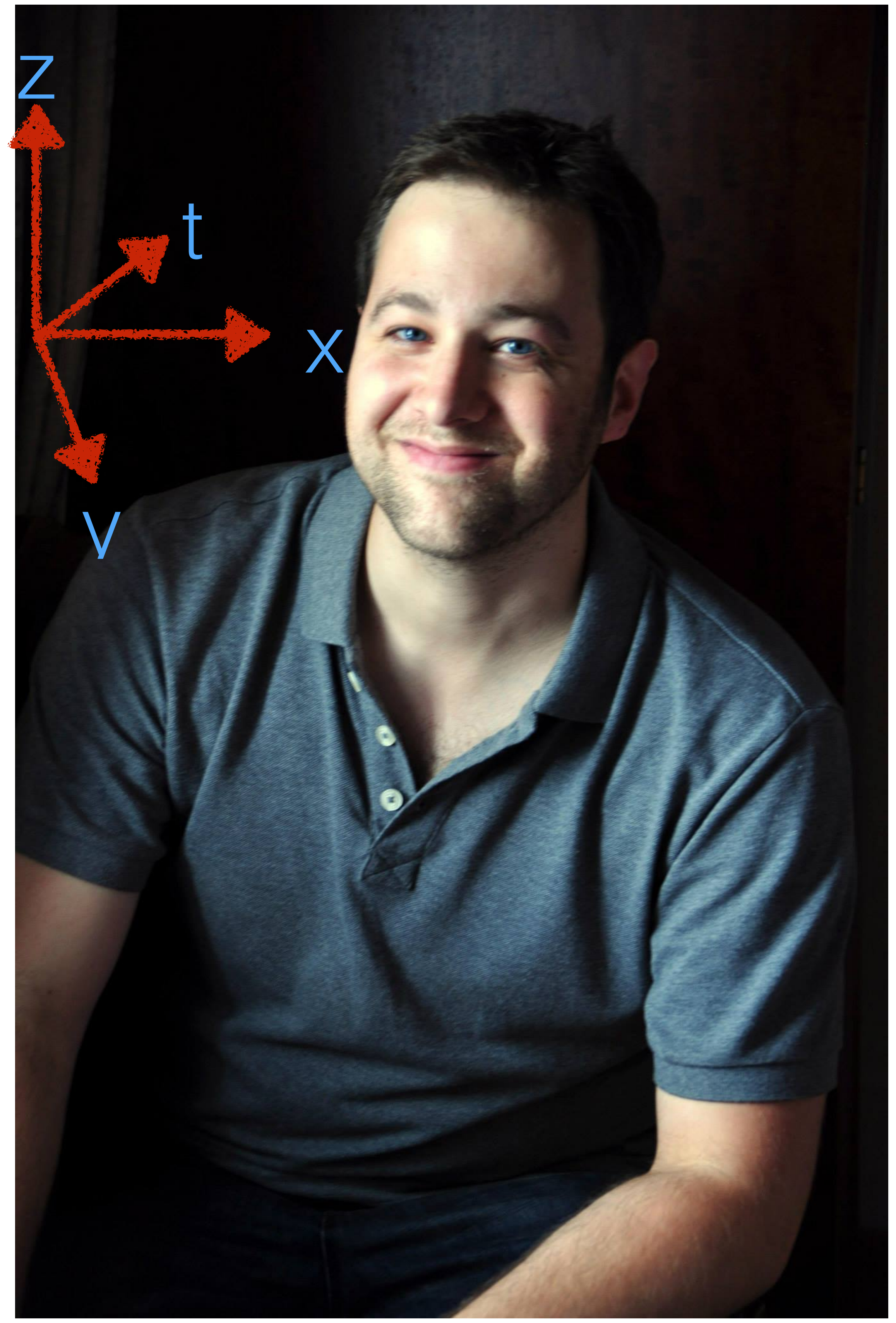
HEP cluster overview

A bit about me..

- Not a high energy physicist working in high energy physics 🤔
- PhD studies in nuclear structure and reactions (nucleon-nucleon scattering measured with silicon strips, scintillator arrays and drift chambers) UoL / STFC Daresbury / GSI-FAIR
- PDRA positions in HEP group on silicon dosimetry (UoL / Clatterbridge) and proton imaging with silicon detector technology from HEP (UoL / iThemba)
- Now a 'core' physicist working on silicon pixel detectors for the ATLAS ITk upgrade at CERN and silicon photomultiplier detectors for Darkside-20k at LGNS as well as detector R&D for medical applications



Warning: This photo no longer accurately represents the subject who's dimensions have grown on at least two axis since it was taken

HEP People

People

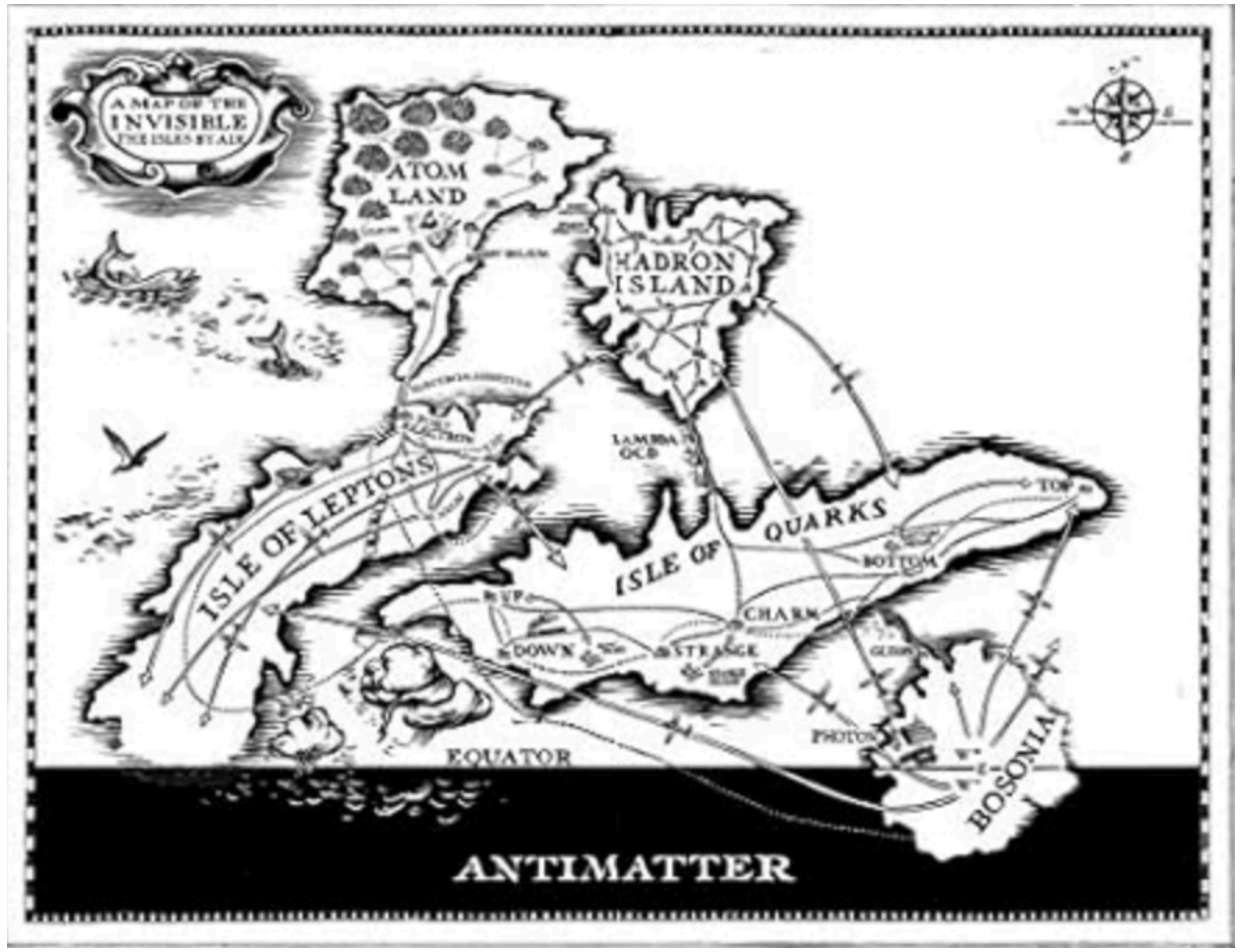
- 24 x academic staff
- 20 x PDRAs
- 8 x non-academic research staff
- 7 x technical and engineering staff
- 37 x PhD Students

If you're looking for me - i'm the one reflected in the glass

HEP Research themes

Matter, Energy, Space and Time! or more precisely…

- Physics beyond the standard model
- Dark Matter and Dark Energy
- Neutrinos
- Detector R&D for future experiments
- Applications of HEP tech: reactor monitoring, dosimetry and medical imaging, mass spectrometry



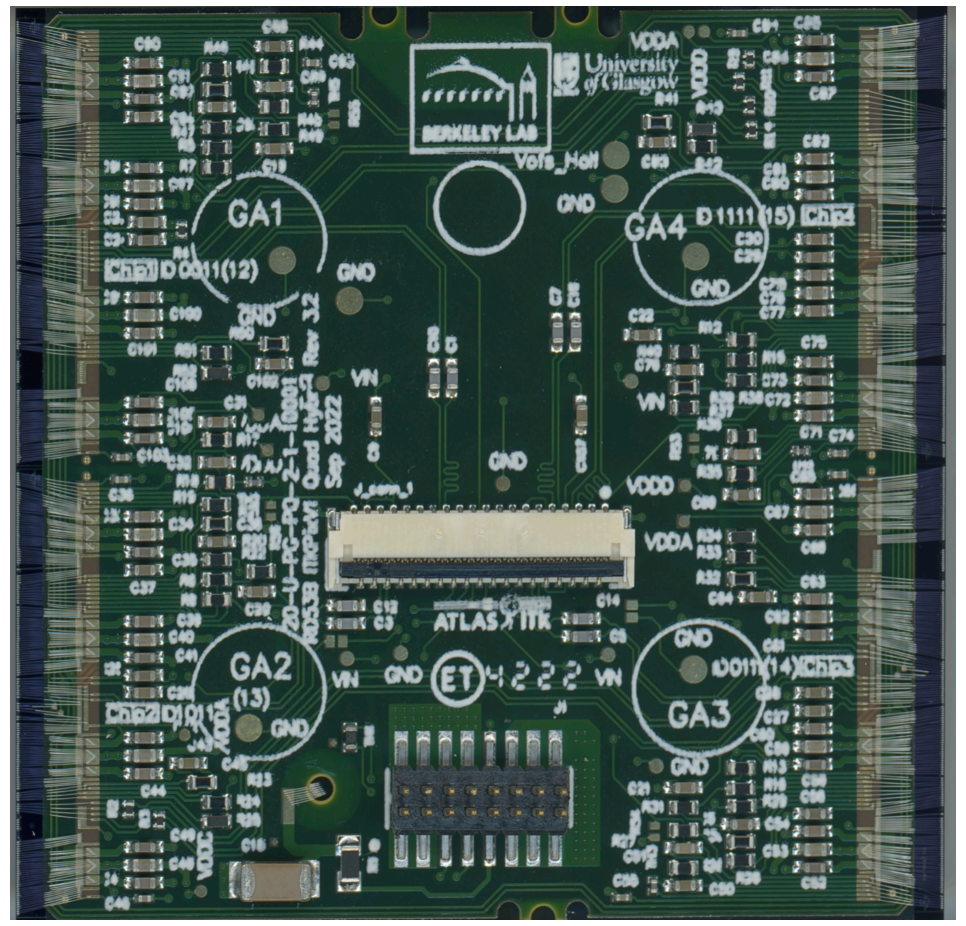
'*A map of the invisible*' J.Butterworth

HEP Places

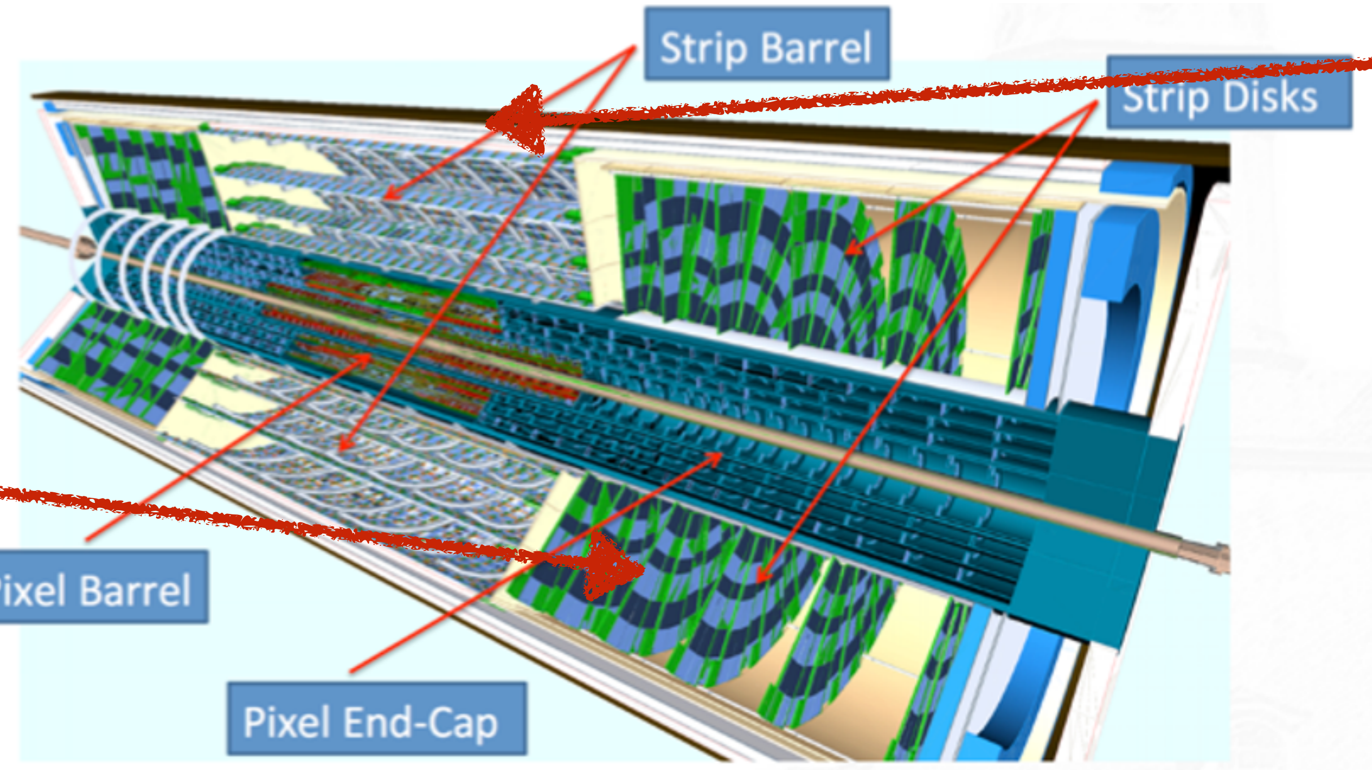
- Permanent / long term attachment: Oliver Lodge, CERN, Daresbury, DESY, FNAL
- Short term trips to the above places and other labs / institutes e.g. PSI, SURF, Boulby are of course also common

Experiments at CERN: ATLAS and LHCb

Hybrid silicon pixel detector 4x4 cm

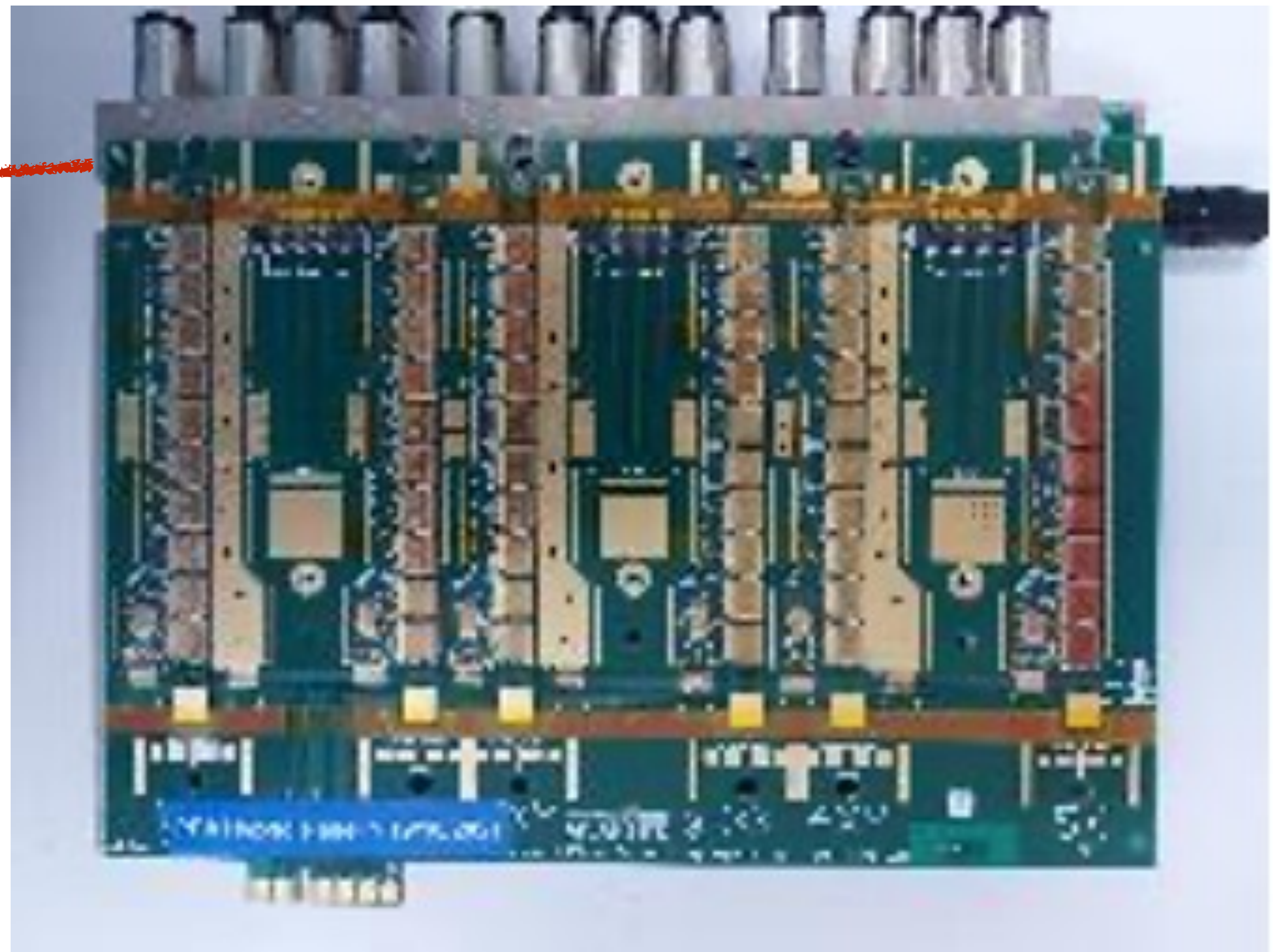


165m^2 of silicon strips, 10mm^2 of silicon pixels, > 1x10^9 channels!

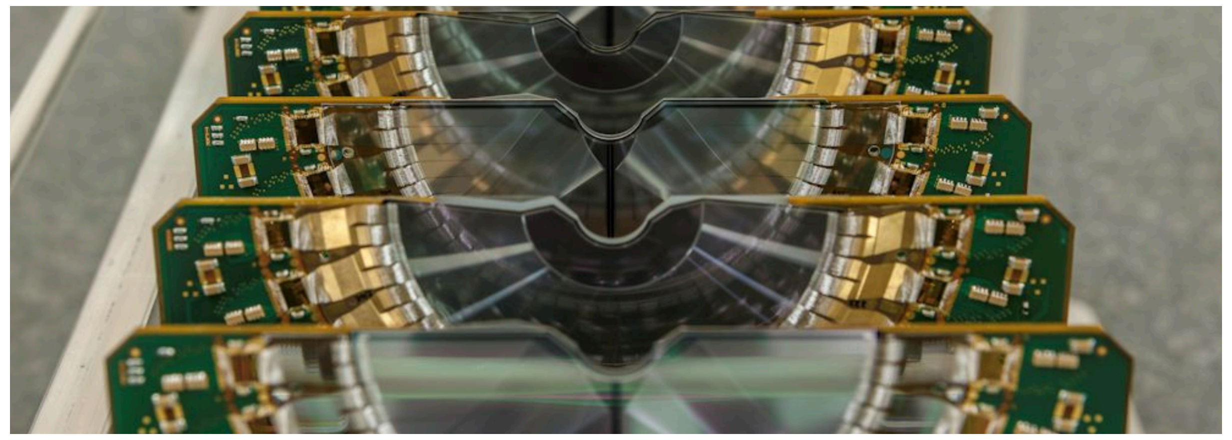


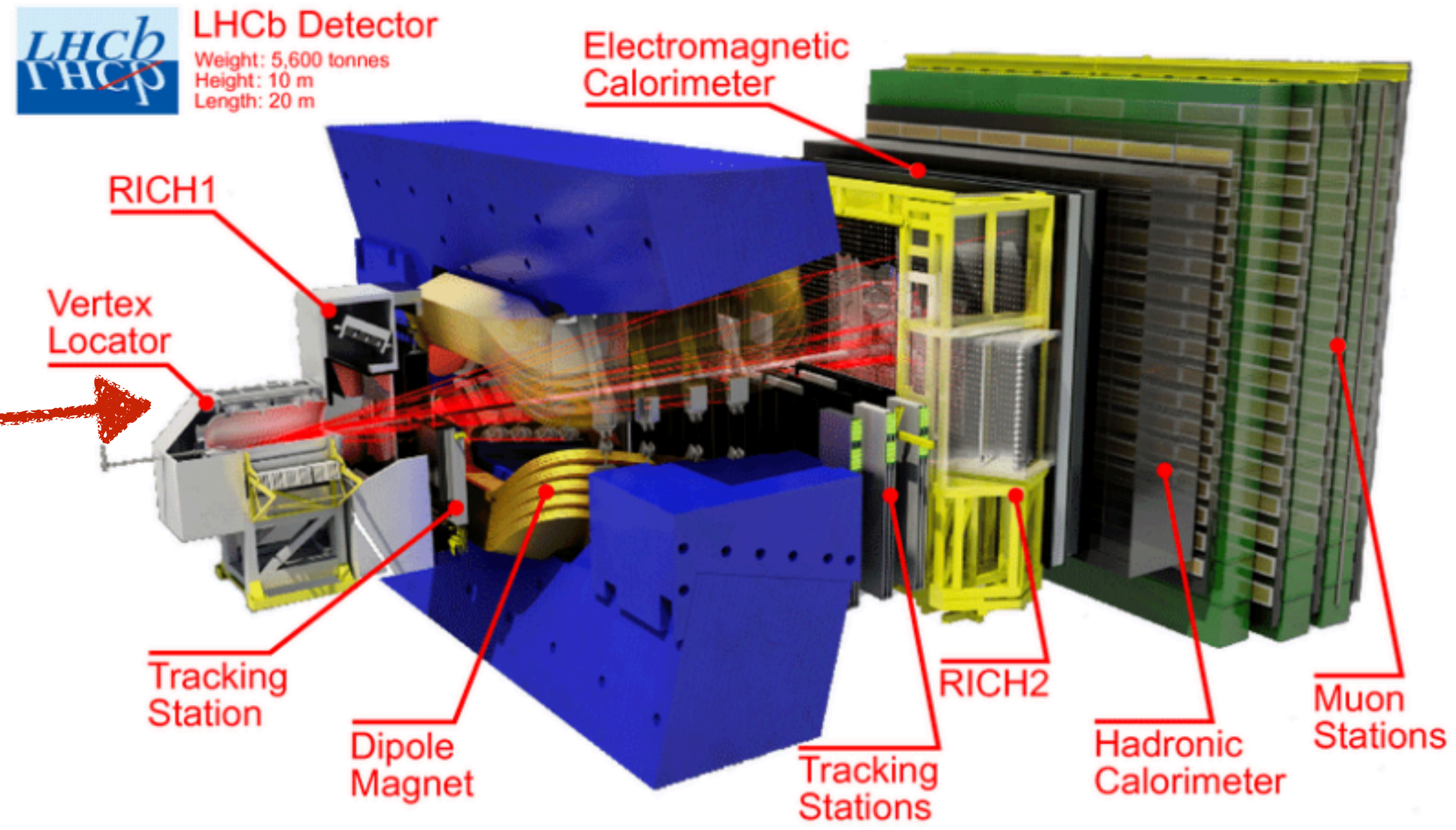
ATLAS Pixel TDR: CERN-LHCC-2017-021 ; ATLAS-TDR-030

Silicon strip module PCBs



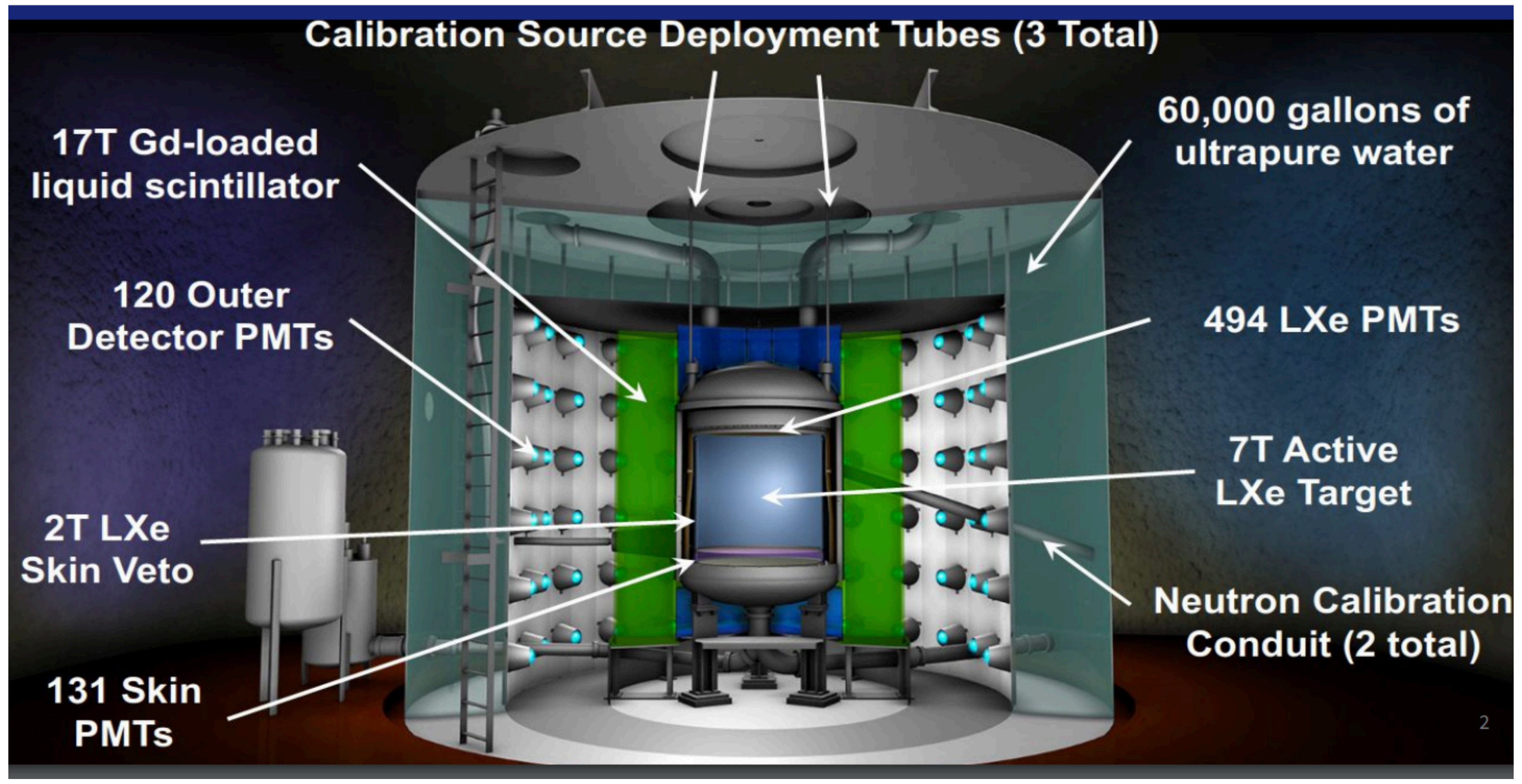
VELO1 and it's upgrade integrated at Liverpool

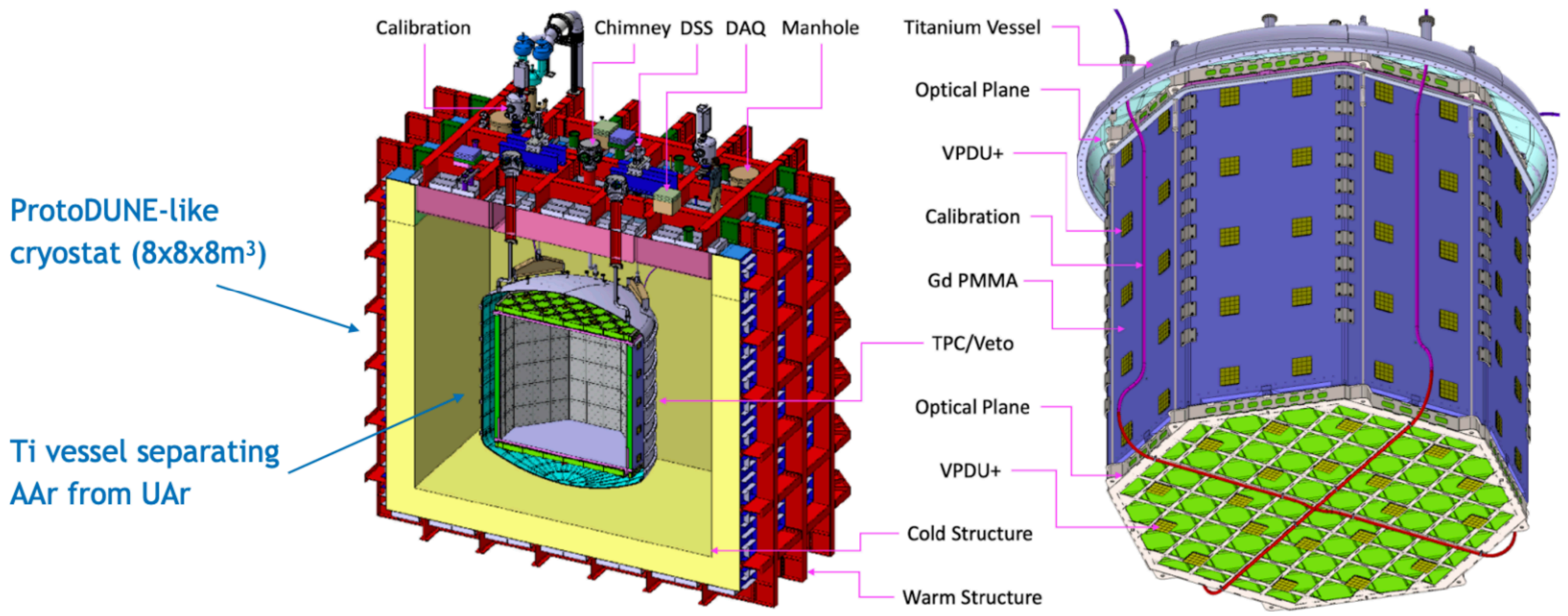




Experiments at SURF and LGNS: LZ, Xenon, Darkside-20k

LZ - Experiment for Direct Detection of WIMP Dark Matter



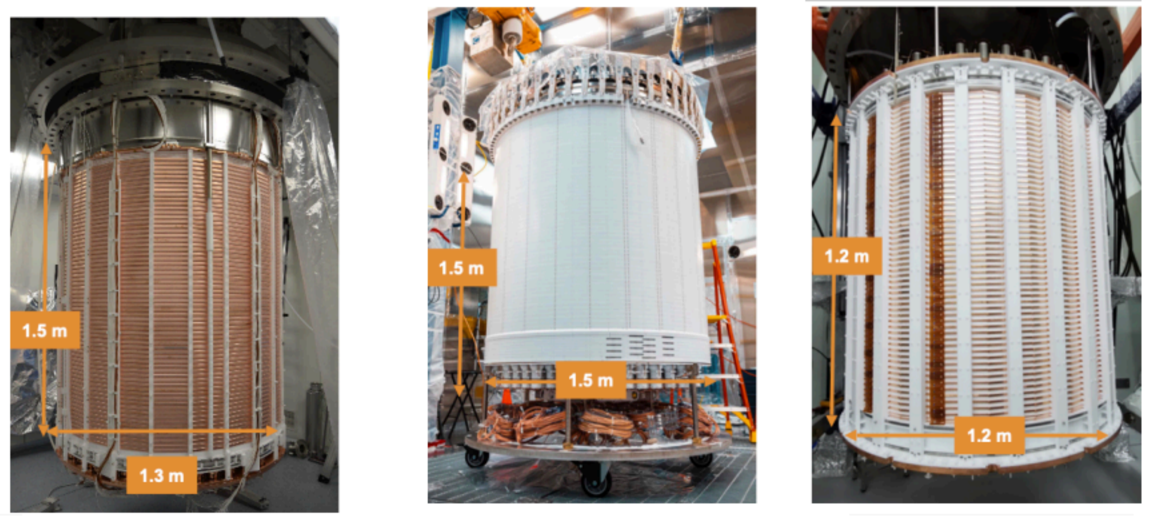


20m² of silicon fabricated by LFoundry in partnership with FBK, Trento.

Experiment at LNGS and cryostat operated at 87K

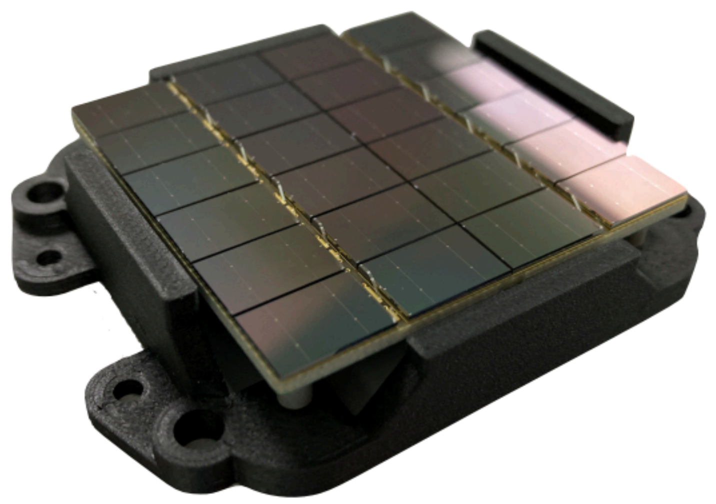
Current Two-phase LXe TPCs for Dark Matter searches

- 3 LXe Dark Matter Search experiments are competing with each other to reach the best sensitivity



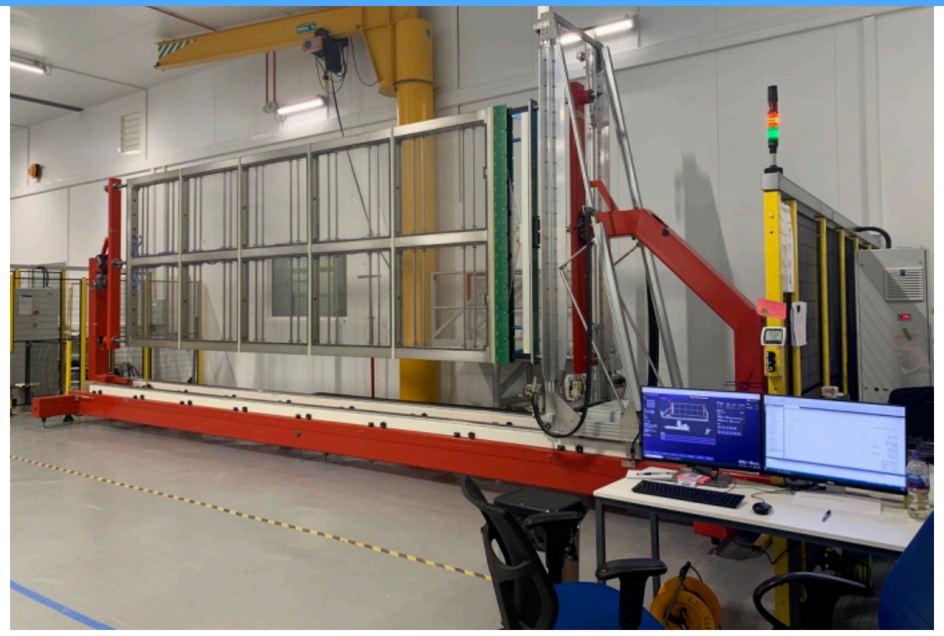
	XENONnT@LNGS	LZ@SURF	PandaX-4T@JinPing
Total (sensitive) mass	8.5 (5.9) tonnes	10 (7) tonnes	5.6 (3.7) tonnes
3-inch PMTs	494	494	368
Drift Field	23 V/cm	193 V/cm	93 V/cm

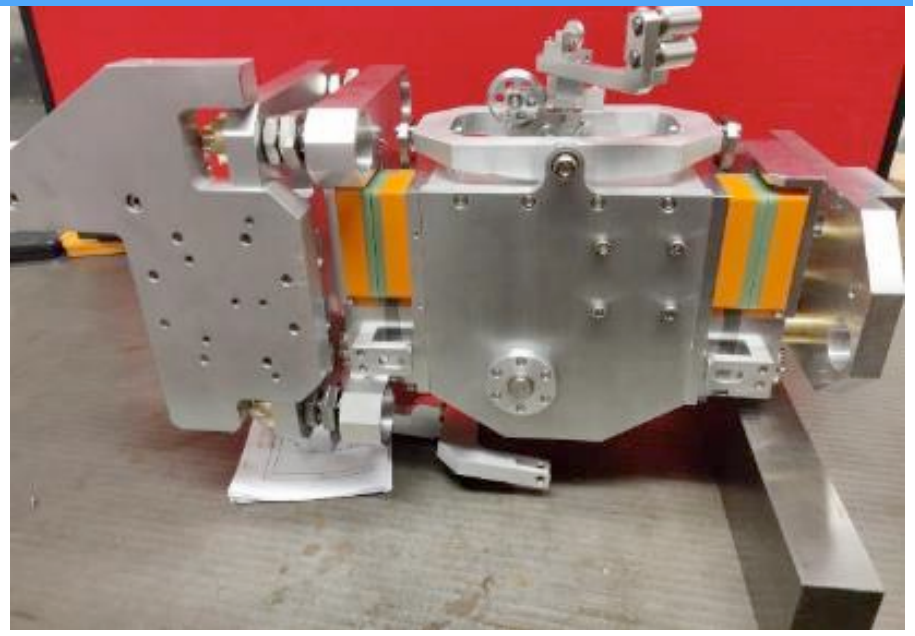
- Liverpool involvement in Gen3 Xenon and LZ experiments
- Darkside-20k is the first dark matter experiment to be instrumented with Silicon PMs
- Darkside-20k outer veto modules currently being built in the LDSC - major production to start soon
- Different challenge - not radiation hard detections but radiation free detectors (mostly just radon free actually) enabling low background measurements



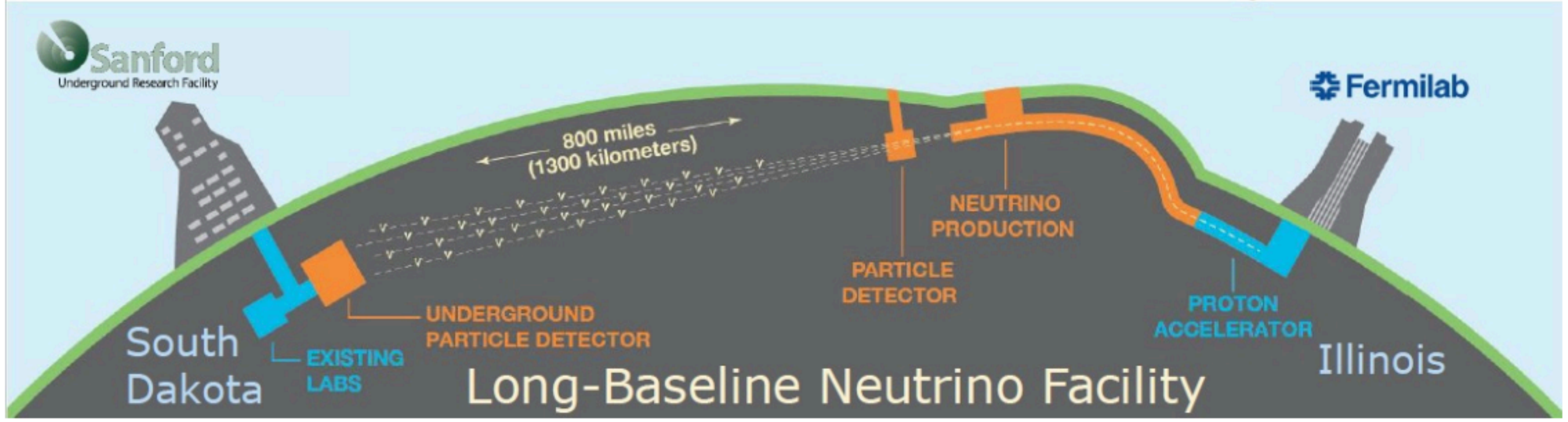
Experiments at Fermilab: g-2 and DUNE

Wire-winding tools for producing APA wire chambers for DUNE

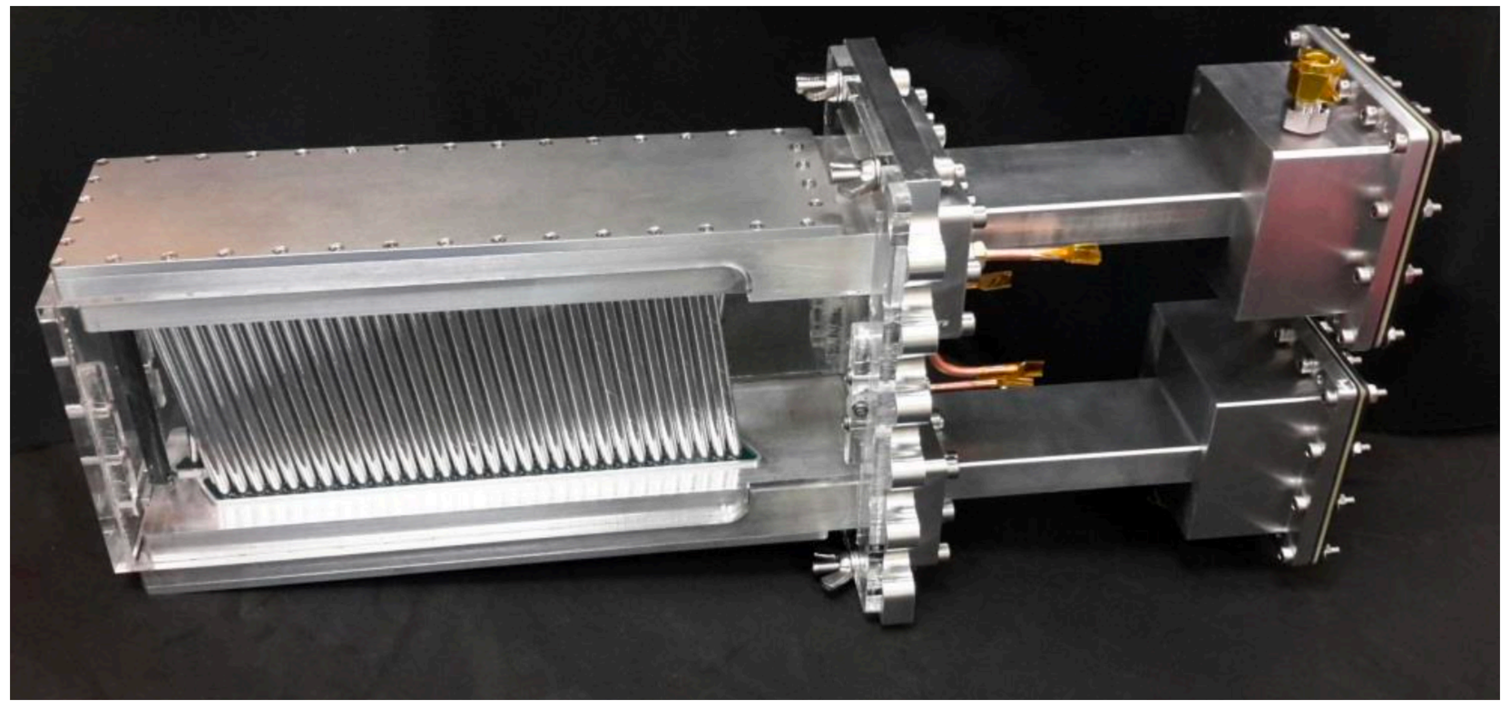


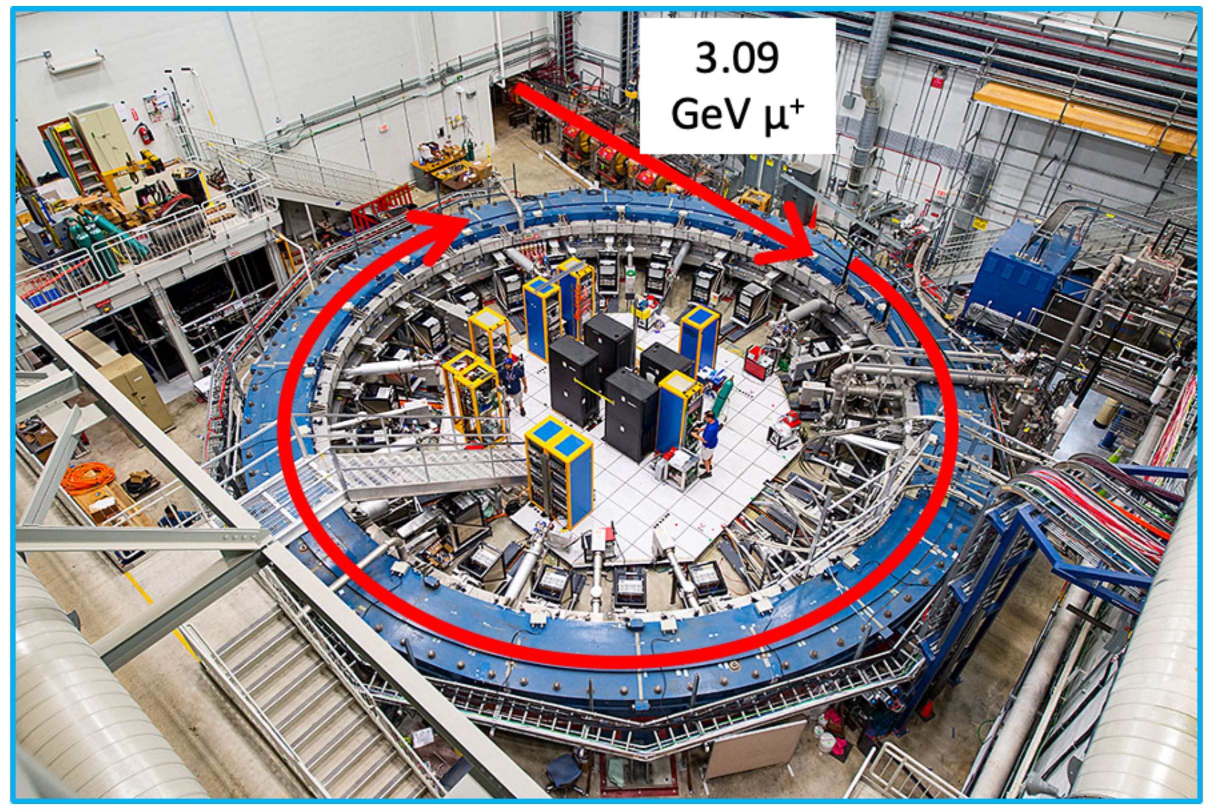


LBNF/DUNE project



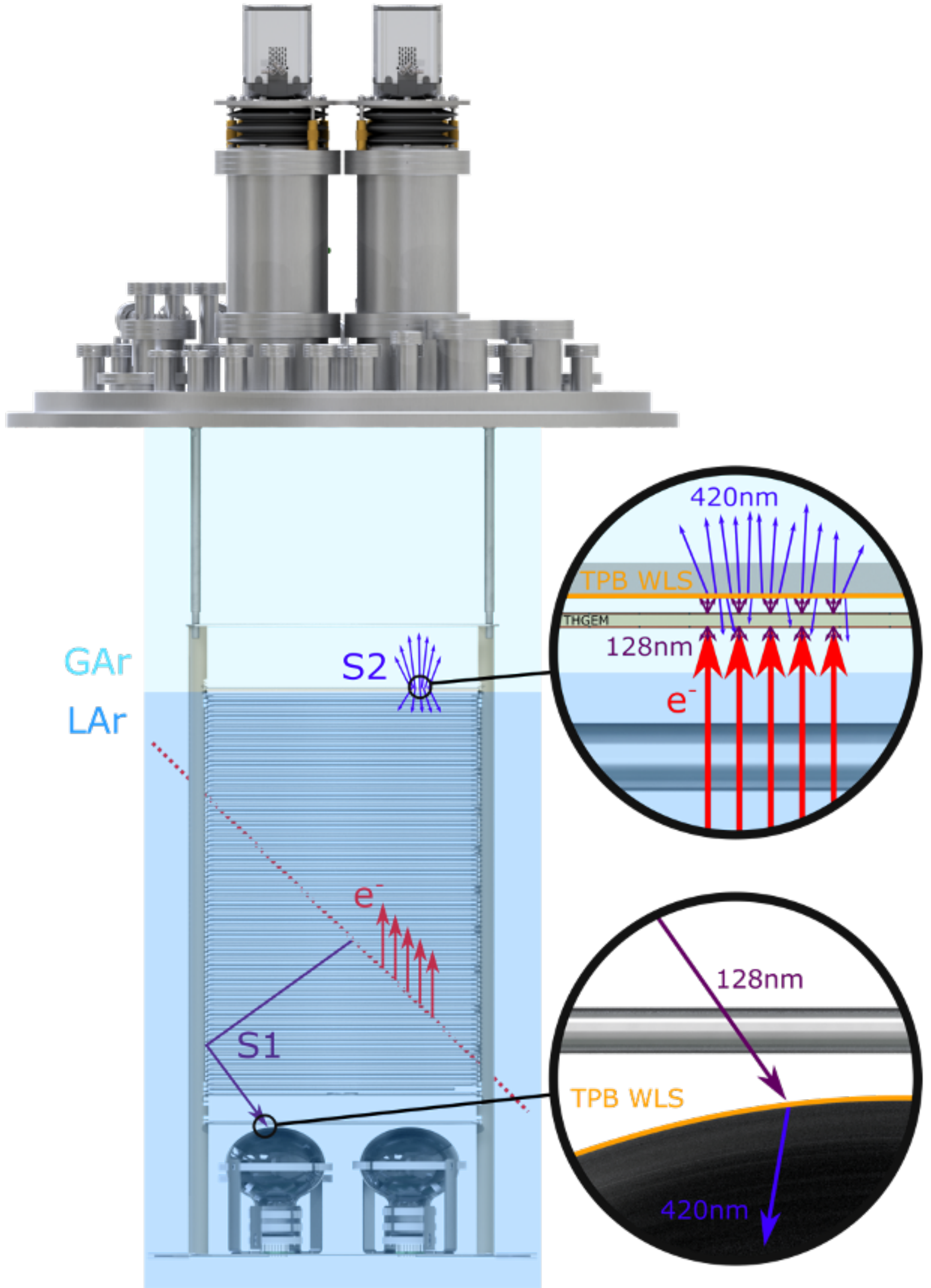
Low mass'Straw trackers' for g-2 experiment





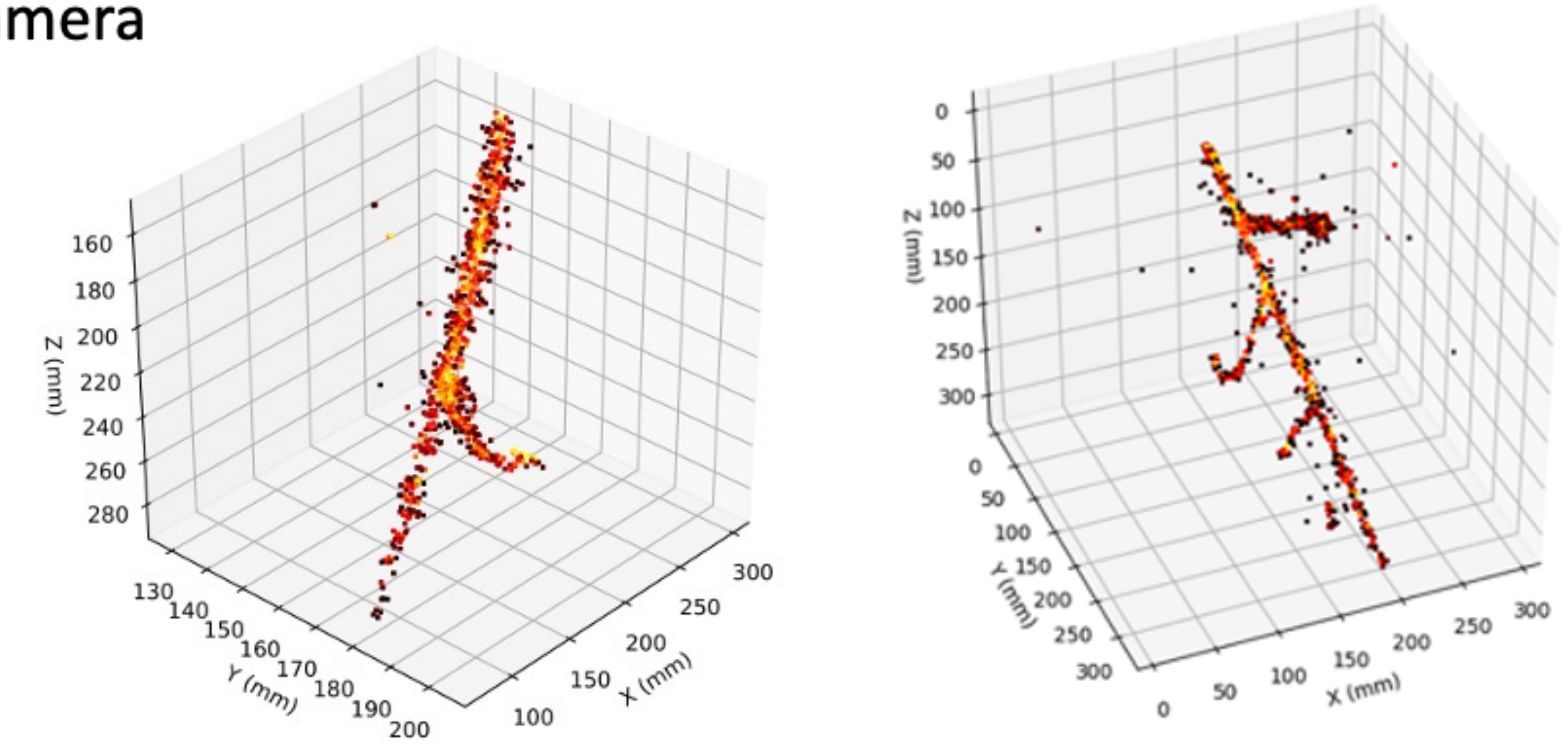
- Silicon is not the only detector material we use - gas detectors are still the best choice for some experiments!

Detector R&D for future experiments: Liquid Argon TPCs



***ARIADNE** (**AR**gon **I**m**A**ging **D**etectio**N** chamb**E**r)*

- Incoming particles ionise LAr and create **prompt scintillation** light (**S1**)
- Electrons drift towards the **extraction grid** situated below the liquid level
- A **THGEM** (THick-Gaseous Electron Multiplier) amplifies drift charge (capable of >30 kV/cm in LAr) generating **secondary scintillation** light (**S2**)
- **WLS** (Wavelength Shifting) before imaging with Timepix3 camera



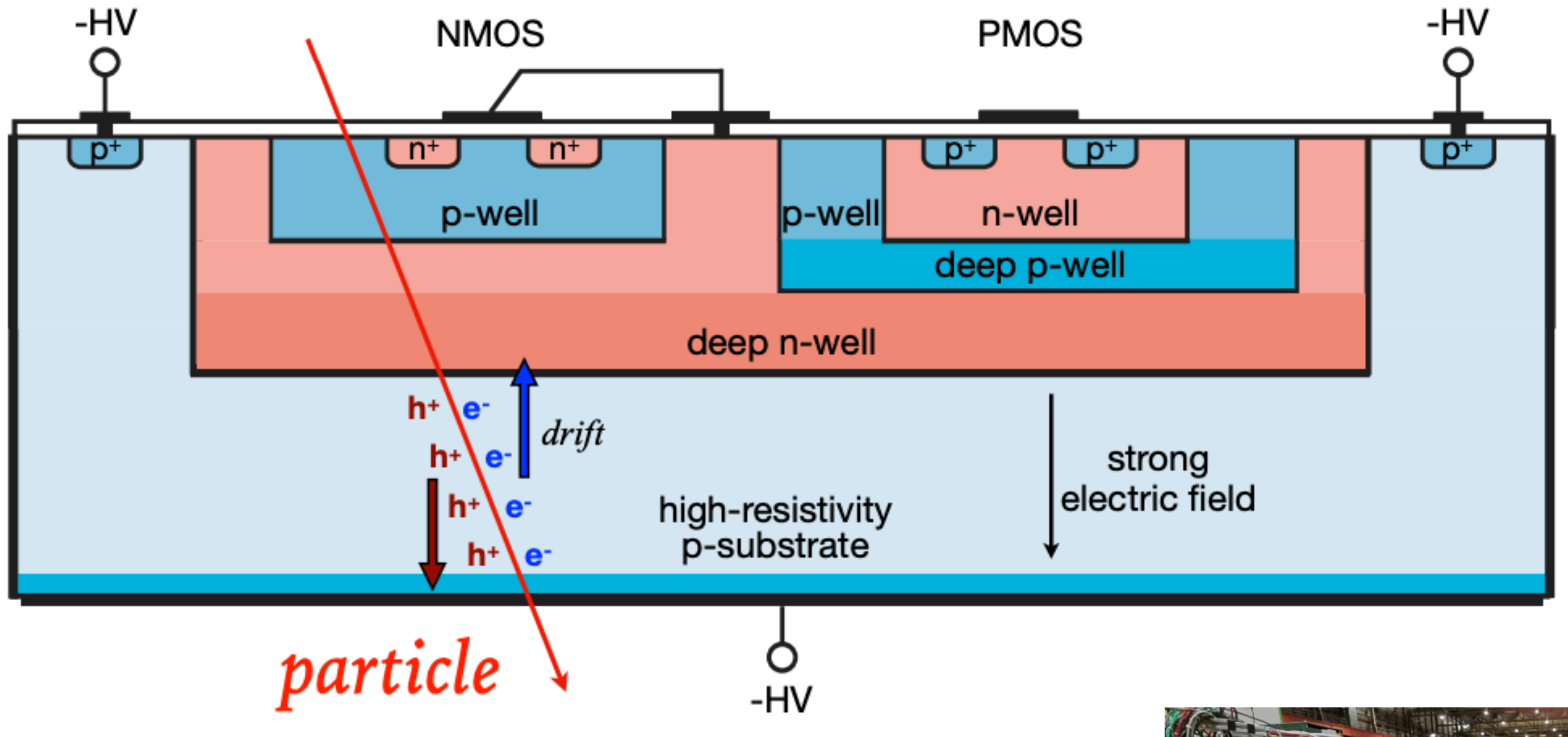
Detector R&D for future experiments: HV-CMOS

Integrated Readout Circuitry:

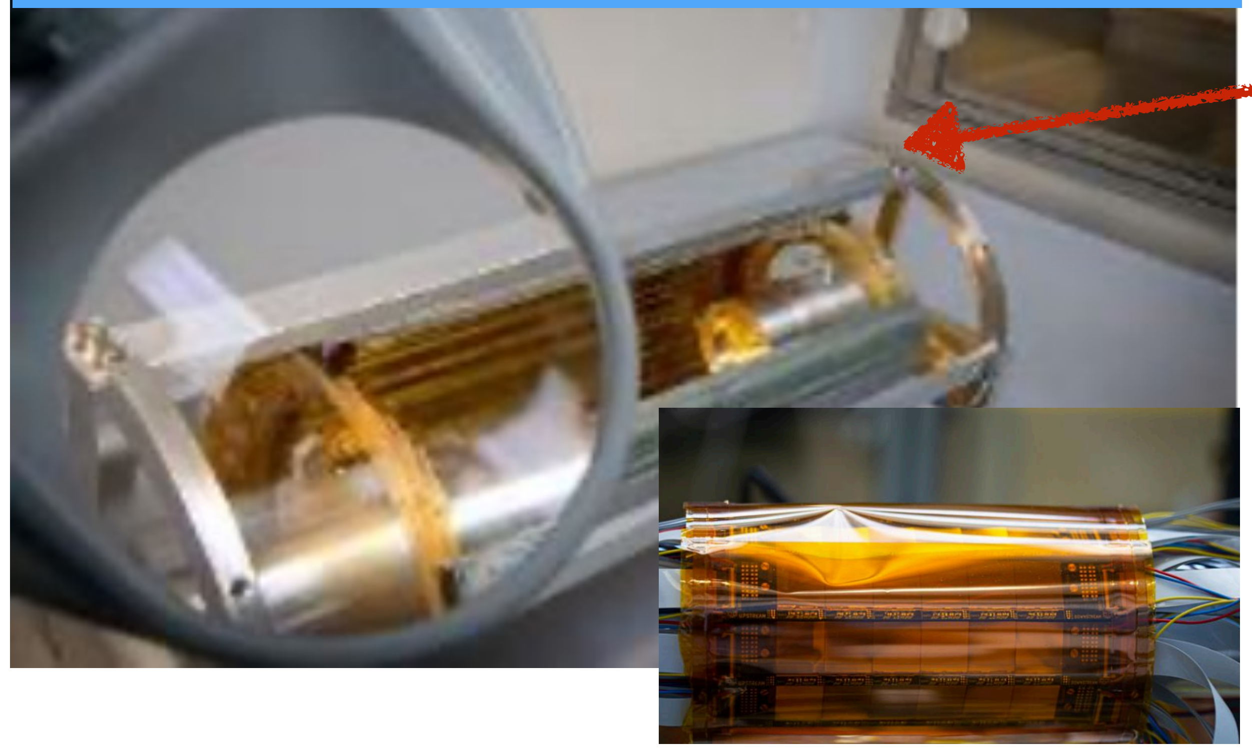
- ✔ Thin sensors
- ✔ Industrial standard
- ✔ Cost effective

High Voltage Pixel:

- ✔ More radiation tolerant
- ✔ Fast charge collection (Drift)

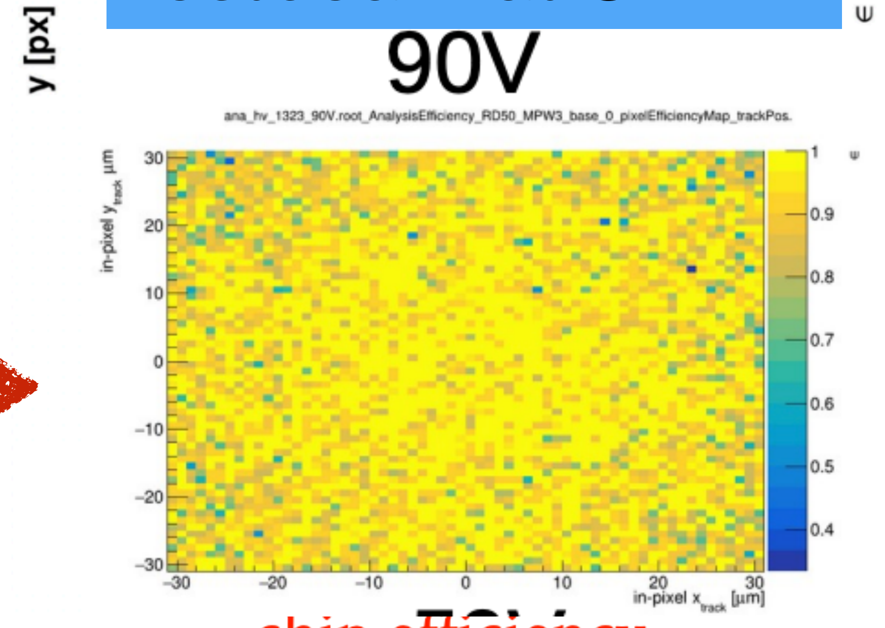


Mu3e assembly and mechanical tooling in the LSDC



- HV-CMOS sensors now being deployed in HEP experiments being worked on in Liverpool e.g. Mu3e in PSI, Switzerland
- Testing of new sensor designs at 'testbeams' allows extraction of their position resolution and efficiency

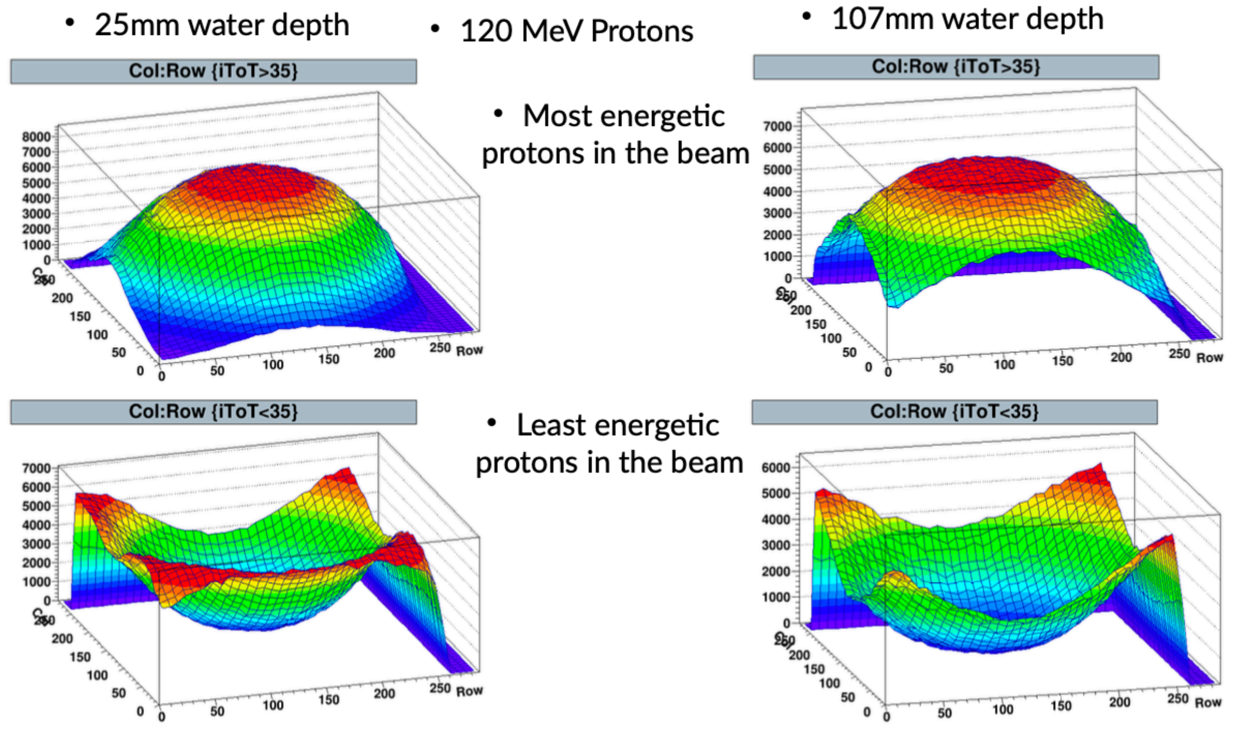
Testbeam at CERN



Detector R&D for medical applications

Protons measured in silicon in a water phantom

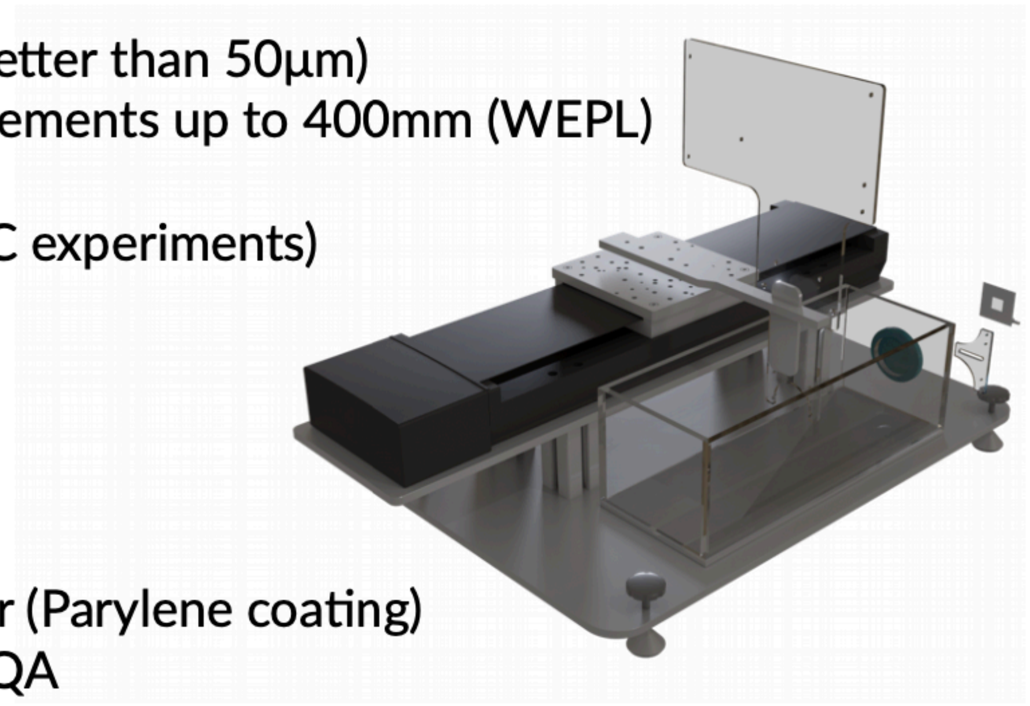
ProteusOne beam profile and Energy measurements with Timepix3 chip



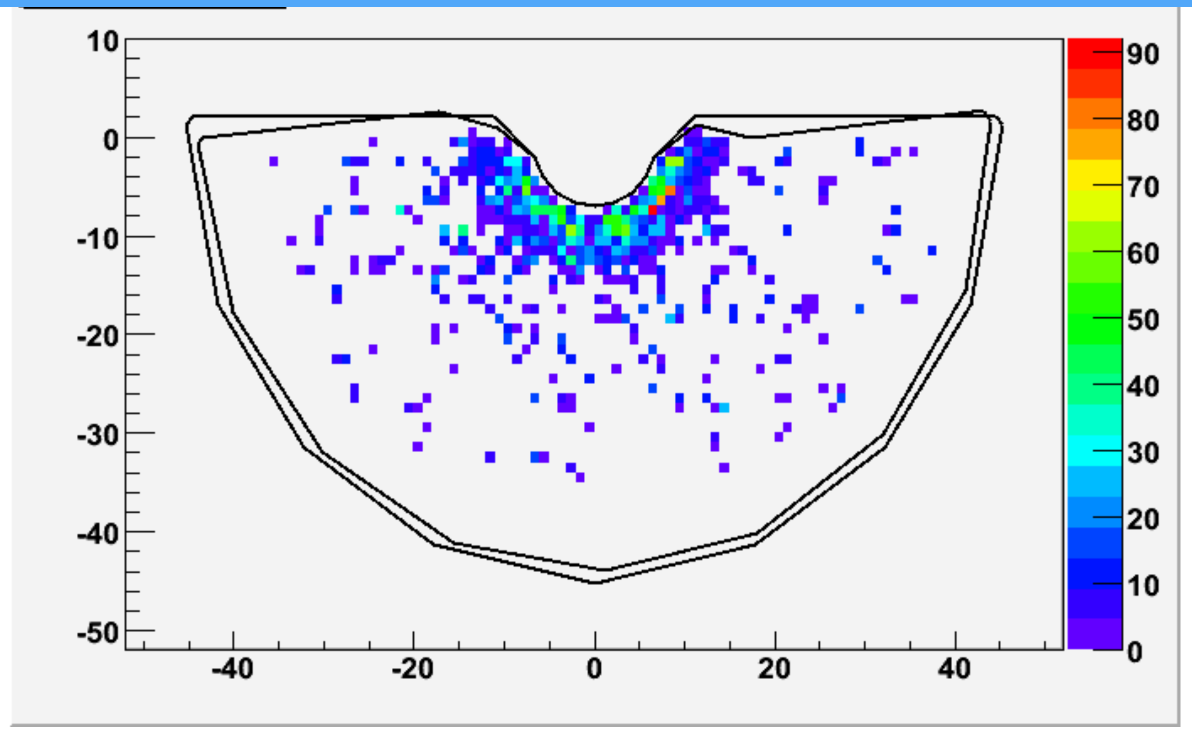
Phantom
- Compact water tank design
- Highly accurate detector positioning (better than 50µm)
- High resolution 3D dose-depth measurements up to 400mm (WEPL)

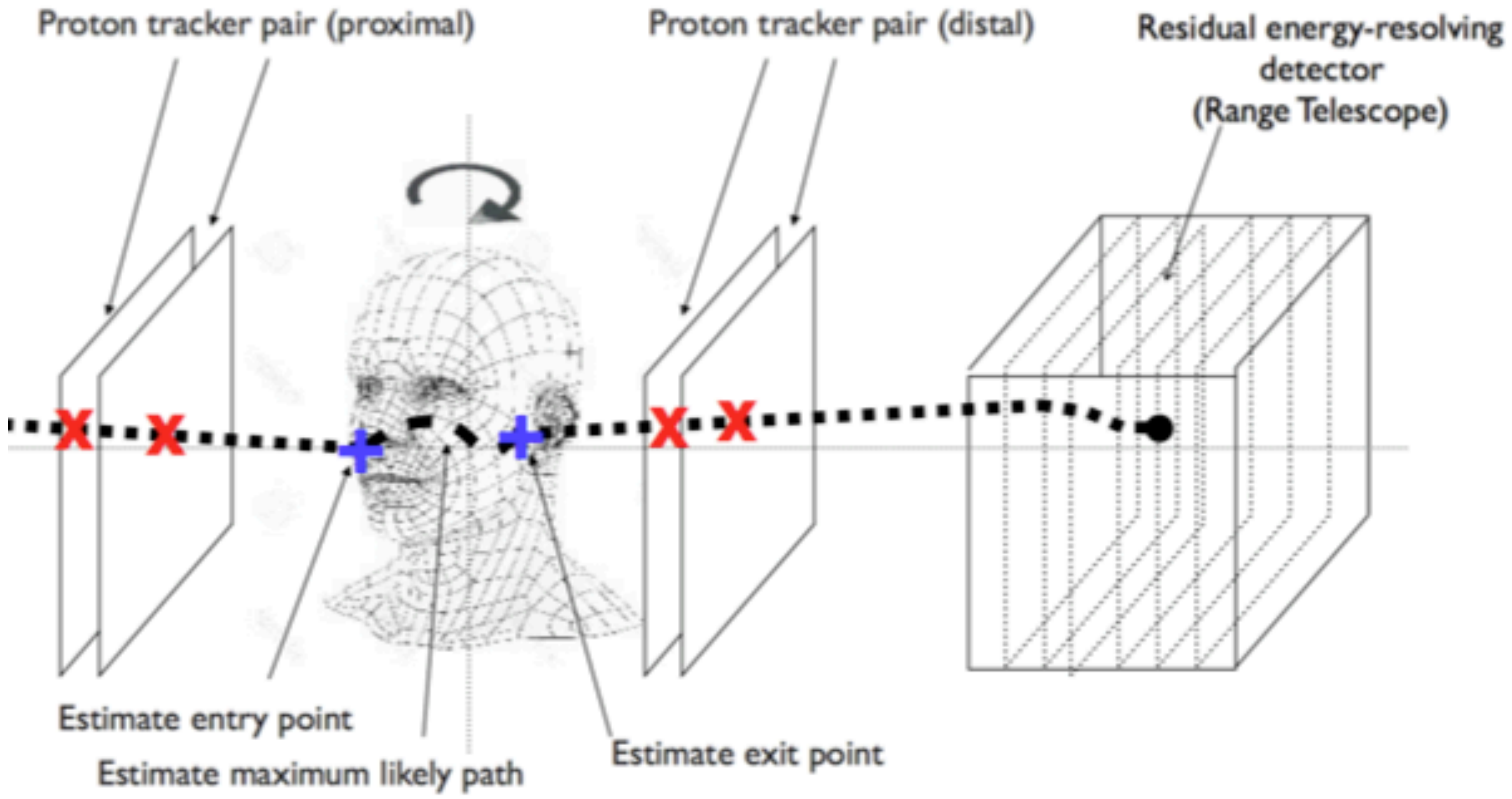
- Silicon Pixel Detectors (from CERN LHC experiments)
  - FeI4 chip (hybrid technology)
  - Timepix3 (hybrid technology)

  - Unique 2D dose-deposition
  - high resolution beam profile QA
  - Measurements directly under water (Parylene coating)
  - potential for 3D patient treatment QA



Proton beam 'halo' measured with LHCb VELO detector at Clatterbridge

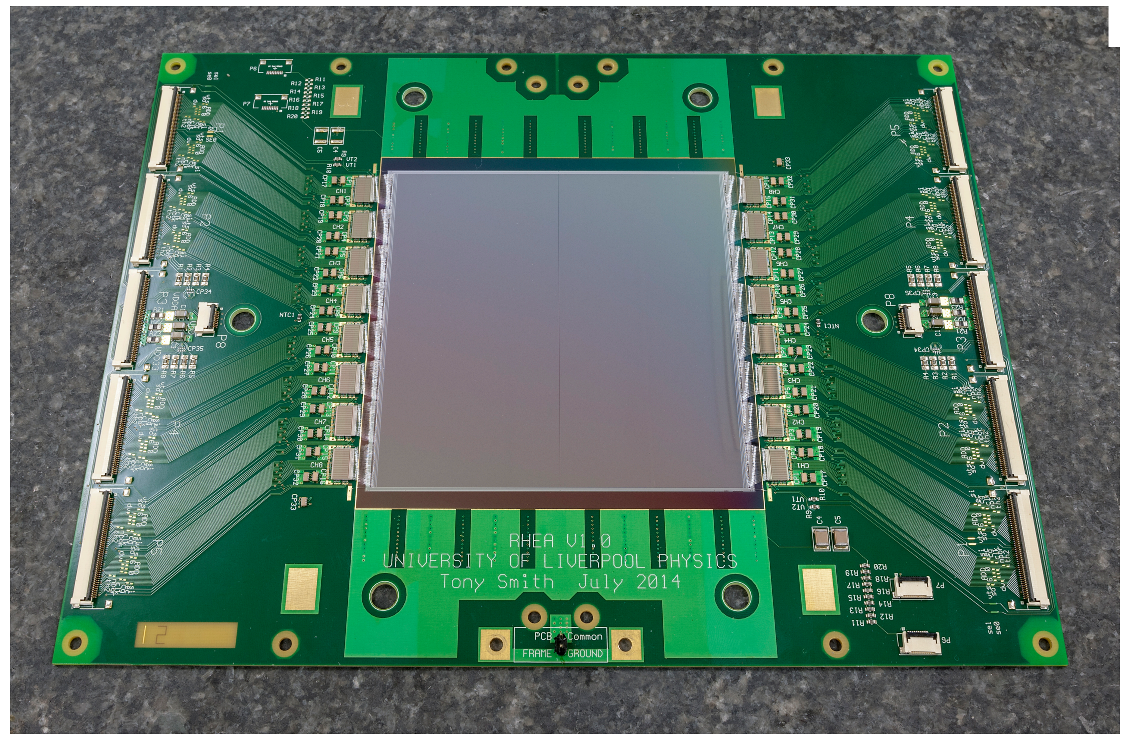




Tracker Paper: J. T. Taylor et al, Med. Phys. Vol. 43, Issue 11 (2016)
Reconstruction Paper: *G.Poludniowski et al, Phys. Med. Biol. 59 (2014)*

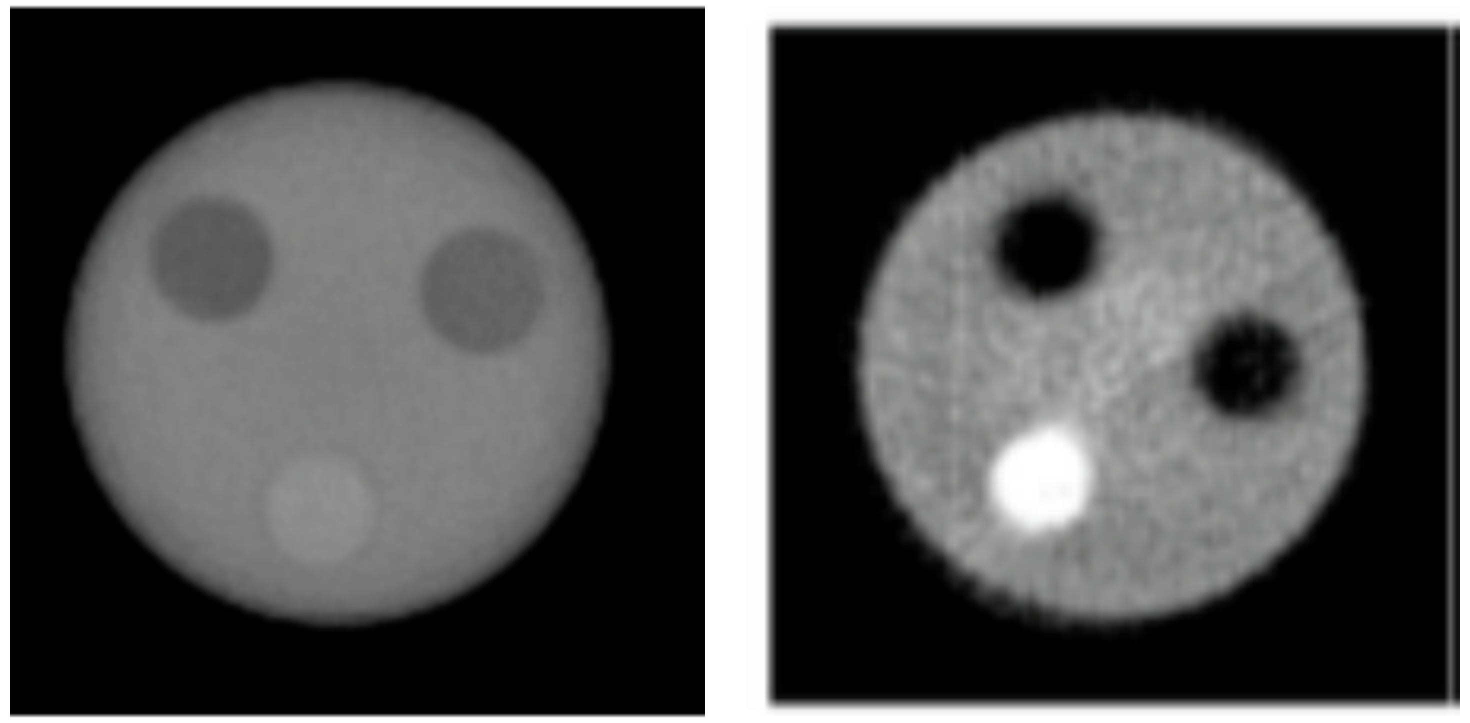
Repeat lots of times ....

Proton radiography and tomography with silicon strip tracker and calorimeter



Silicon strip module developed for proton CT

Scattering and energy | Scattering only



Resulting proton CT images with tissue equivalent inserts visible

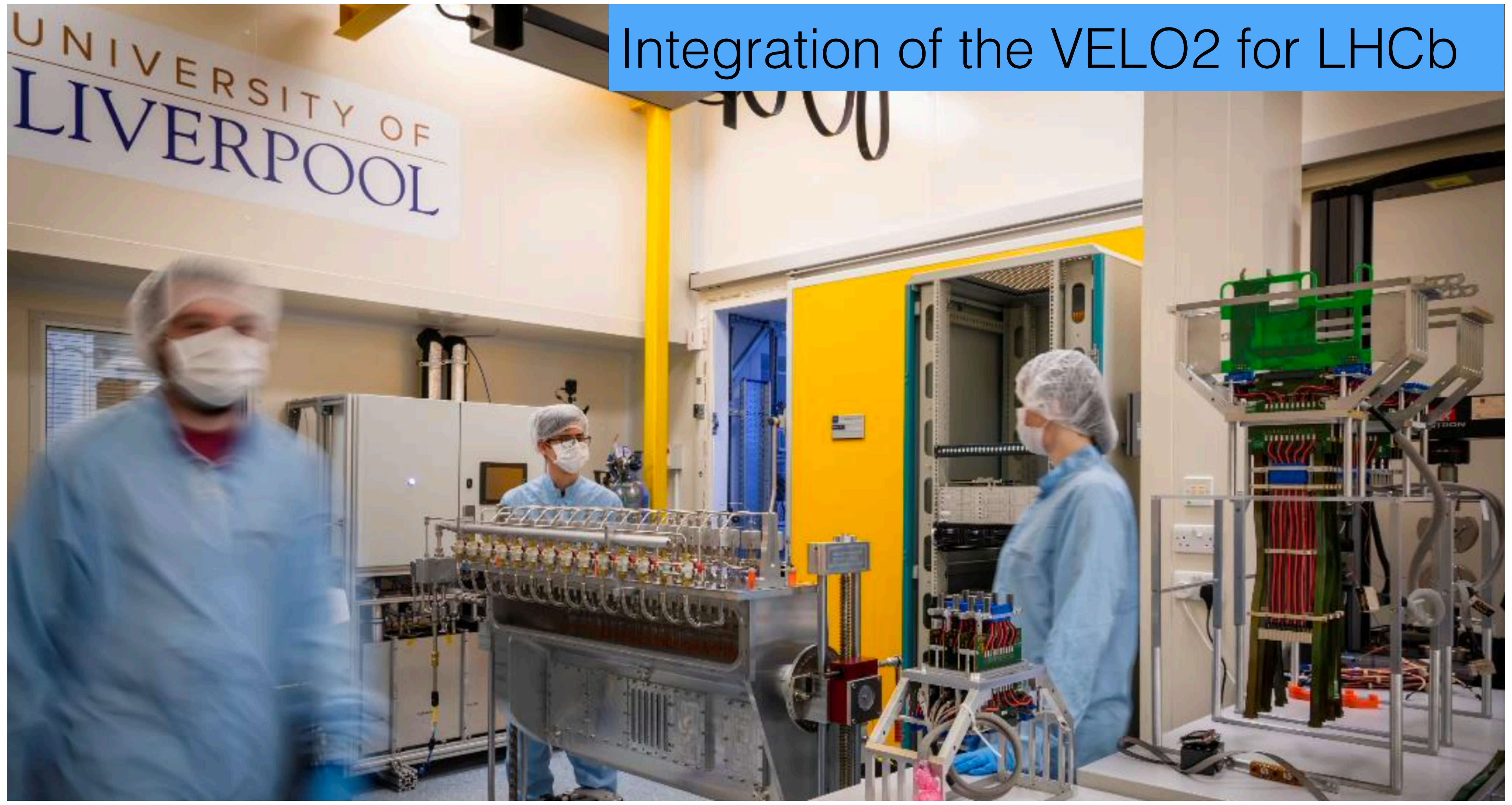
And here's to many more…

- Several other experiments not covered in these slides: MAGIS, FASER, T2K & HyperK, LHCb Mighty Tracker, Mu2e, MUonE, VIDARR, BUTTON, KLOE et al (sorry if there the ones some of you here are working on!)
- In general, my own personal experience has been that it's best to be a part of large collaborations as well as small ones (and preferably at the same time) ie an experiment at a major lab but also an R&D project or smaller scale physics experiments
- In this way, you get the best of both worlds in the sense of collaborative experience and relationships formed as well as the experience of technology and experimental techniques and goals

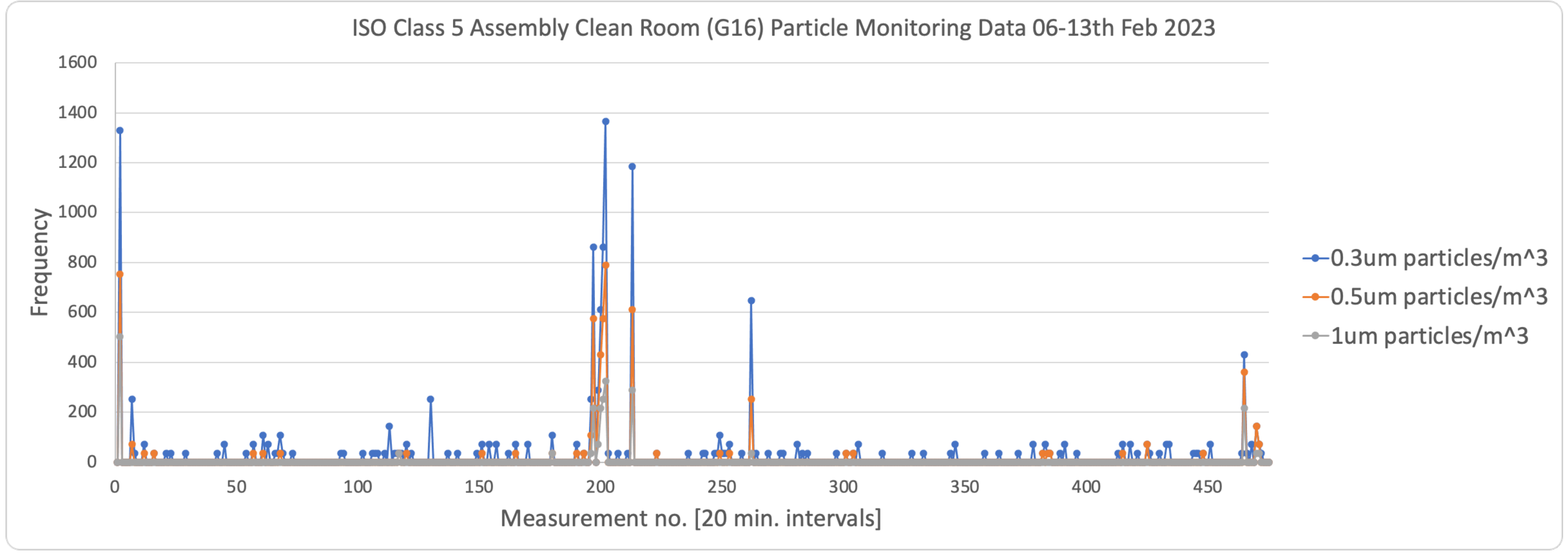
Funding sources

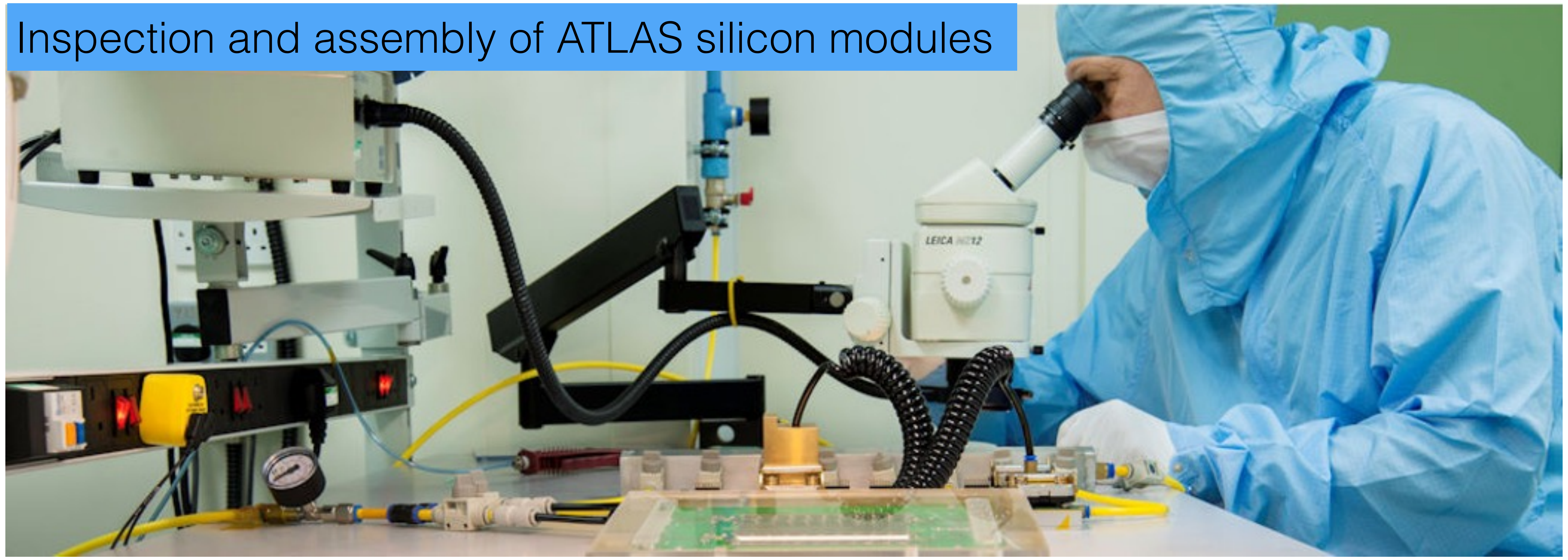
- £22M in active grants
  - Funds core staff and supports £30M of infrastructure within the department
- Main source of funding is STFC and more recently Leverhulme
- Funding (but more often in-kind contributions) also from industry partners / labs: Micron Semiconductor Ltd, Ion Beam Applications (IBA) Ltd, FBK, NPL

Facilities: LSDC



Integration of the VELO2 for LHCb





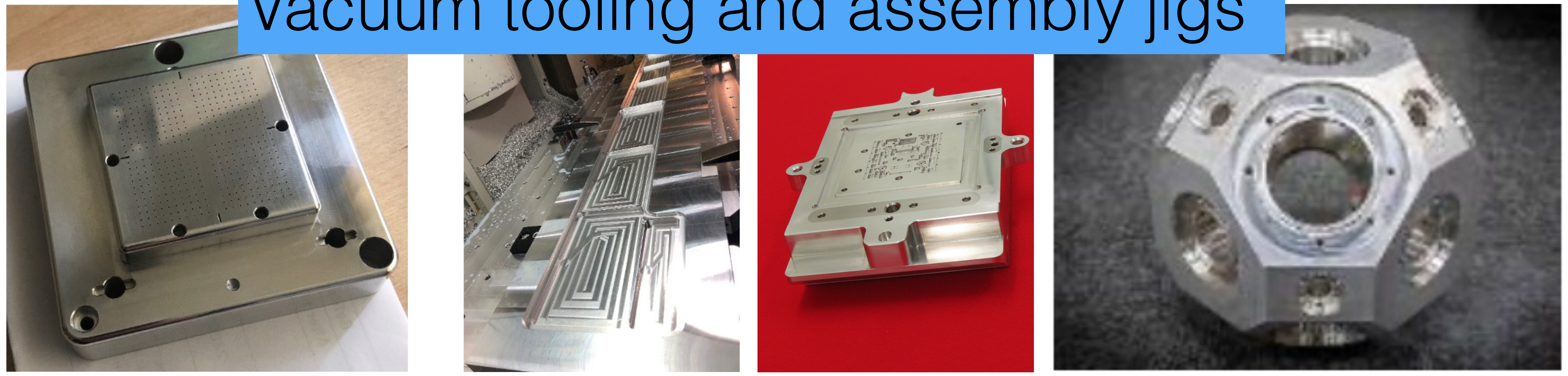
Inspection and assembly of ATLAS silicon modules

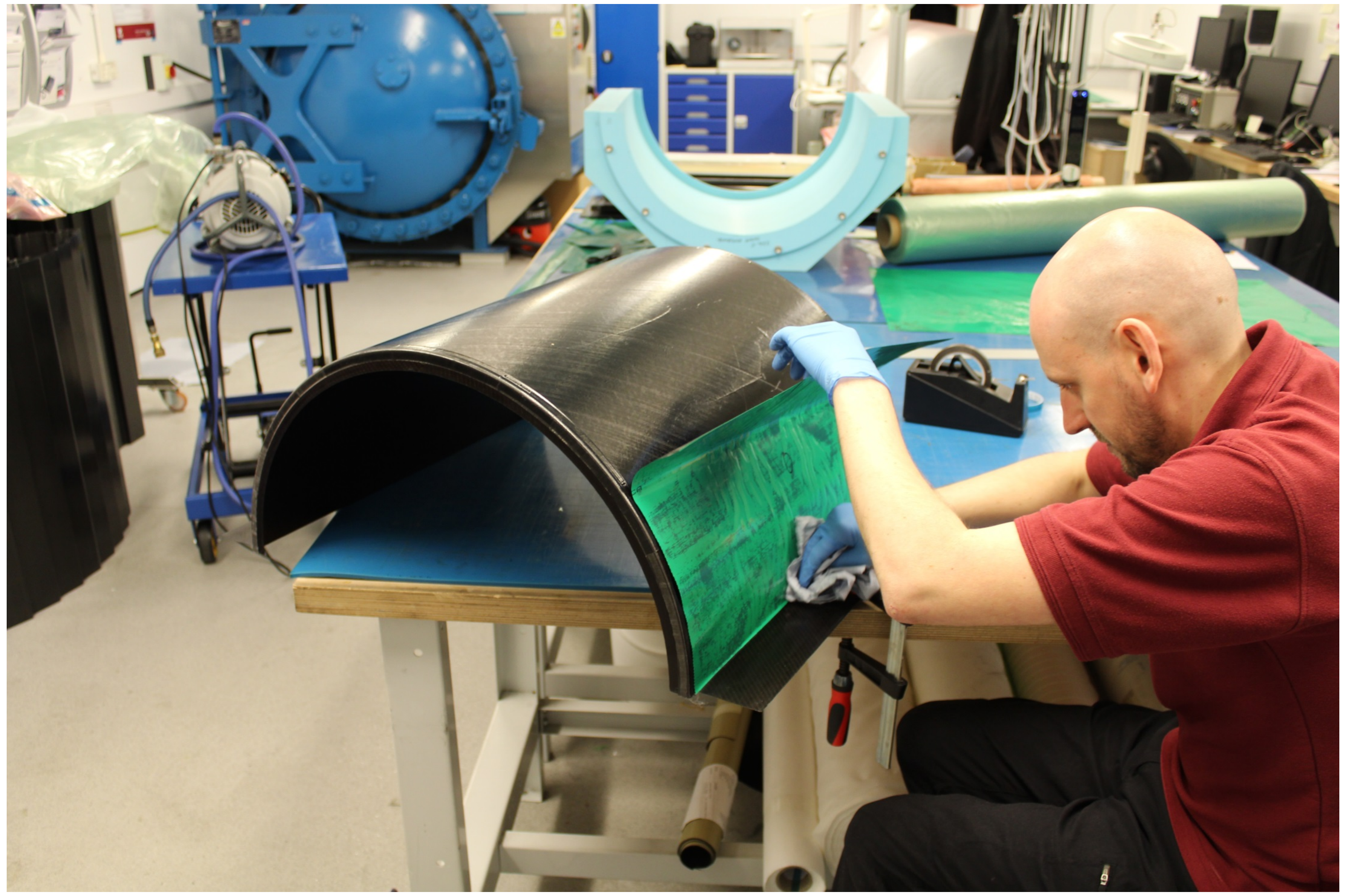
- The Liverpool Semiconductor Detector Centre (LSDC) is a shared facility with the majority of funding coming from STFC (as an SRF facility on the HEP CG)
- Class 5 and class 7 labs available for detector construction, testing and integration
- Several major productions for large scale experiments have been completed in the lab: ATLAS SCT, g-2, LHCb VELO 1&2, ALICE, protoDUNE
- Largest production will be for the future ATLAS ITk

UNIVERSITY OF LIVERPOOL

Facilities: DDMF and AML

Vacuum tooling and assembly jigs

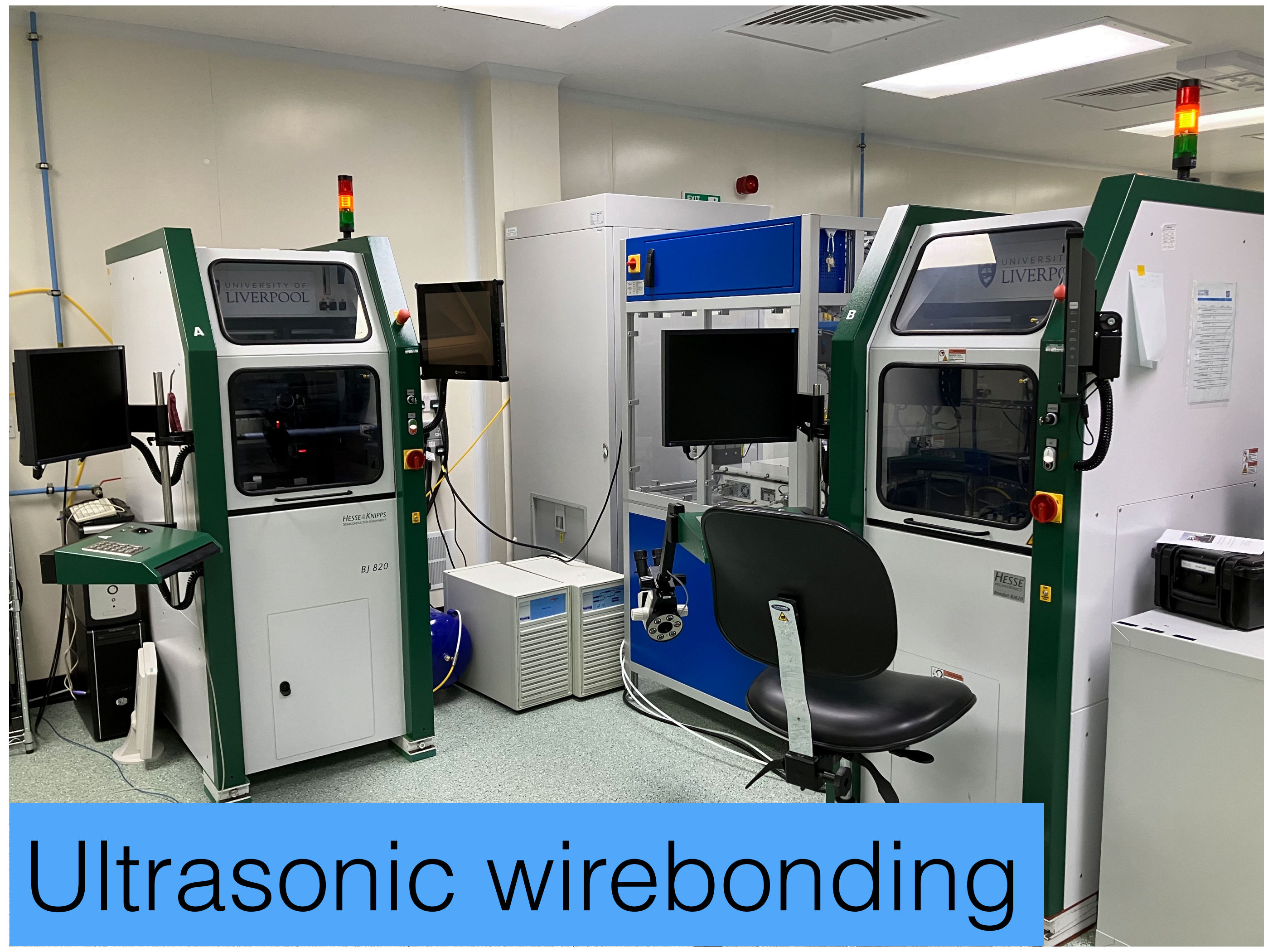


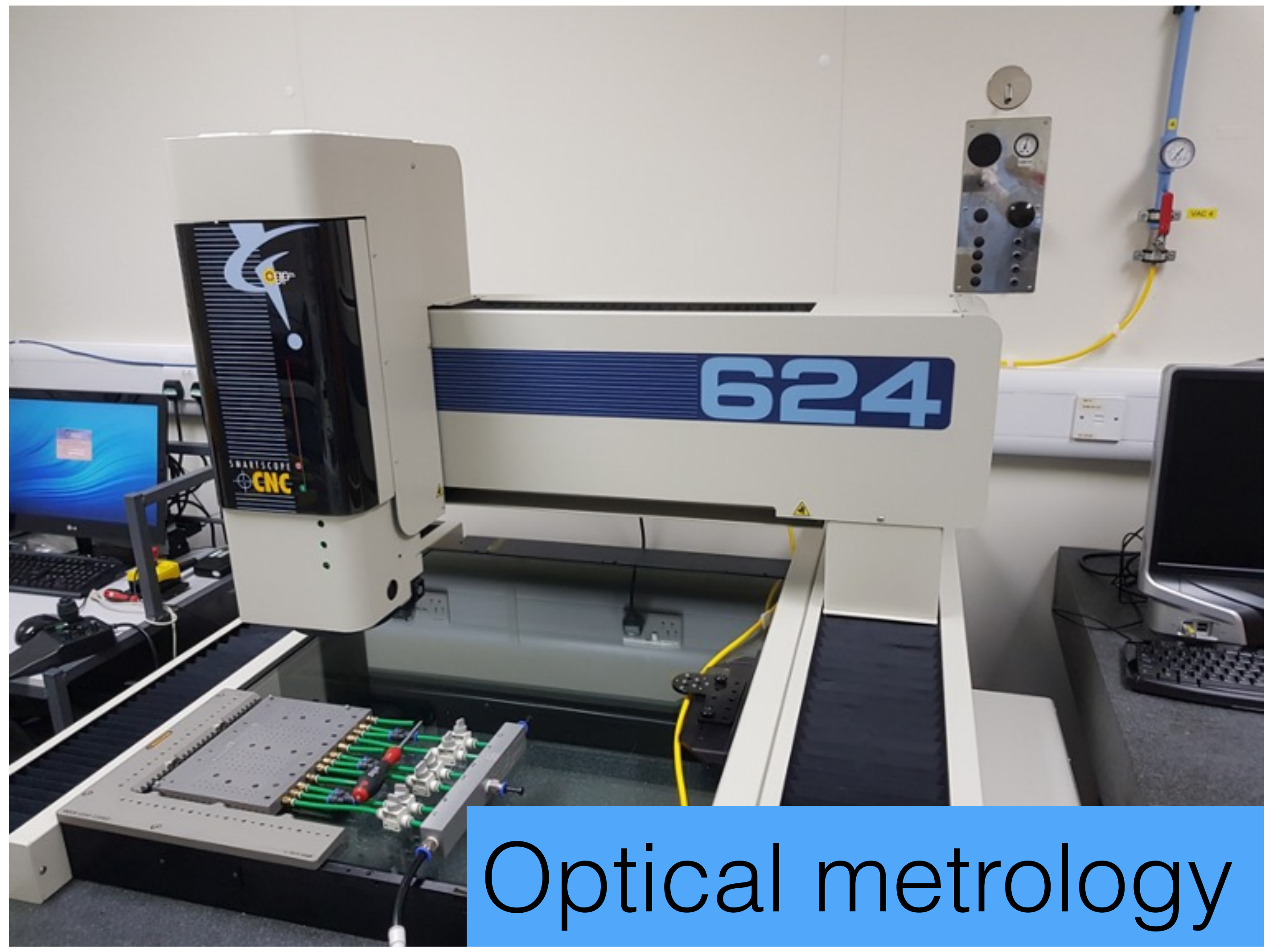


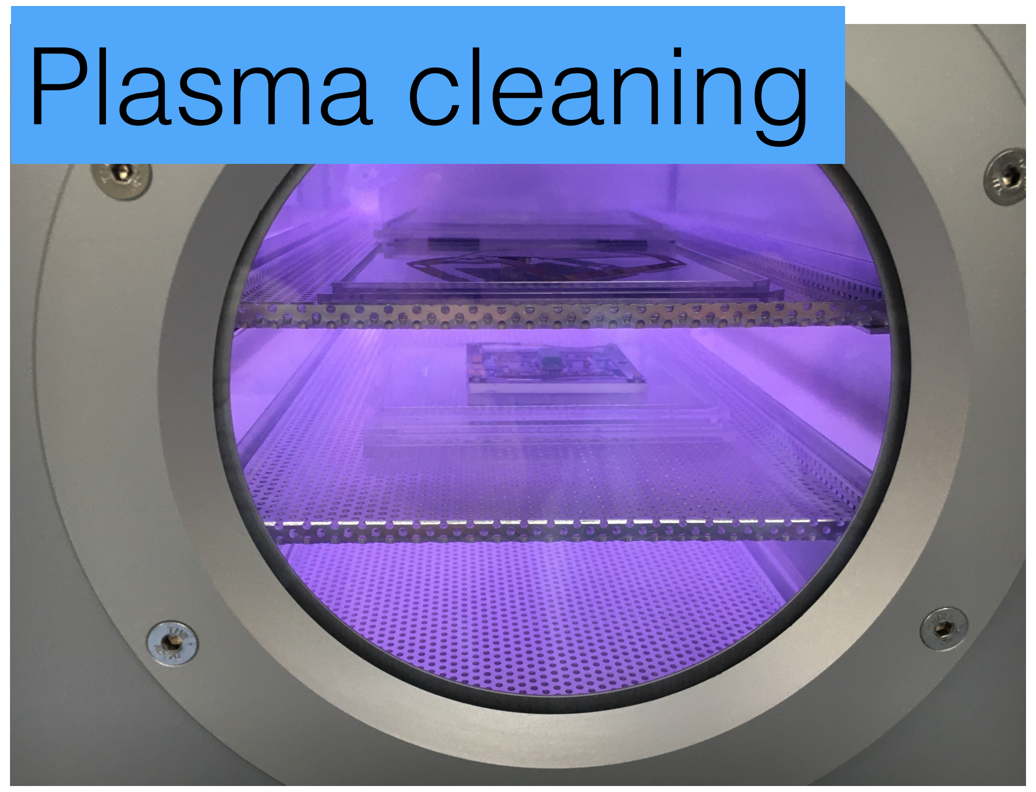
Carbon fibre half shells for ATLAS-ITk

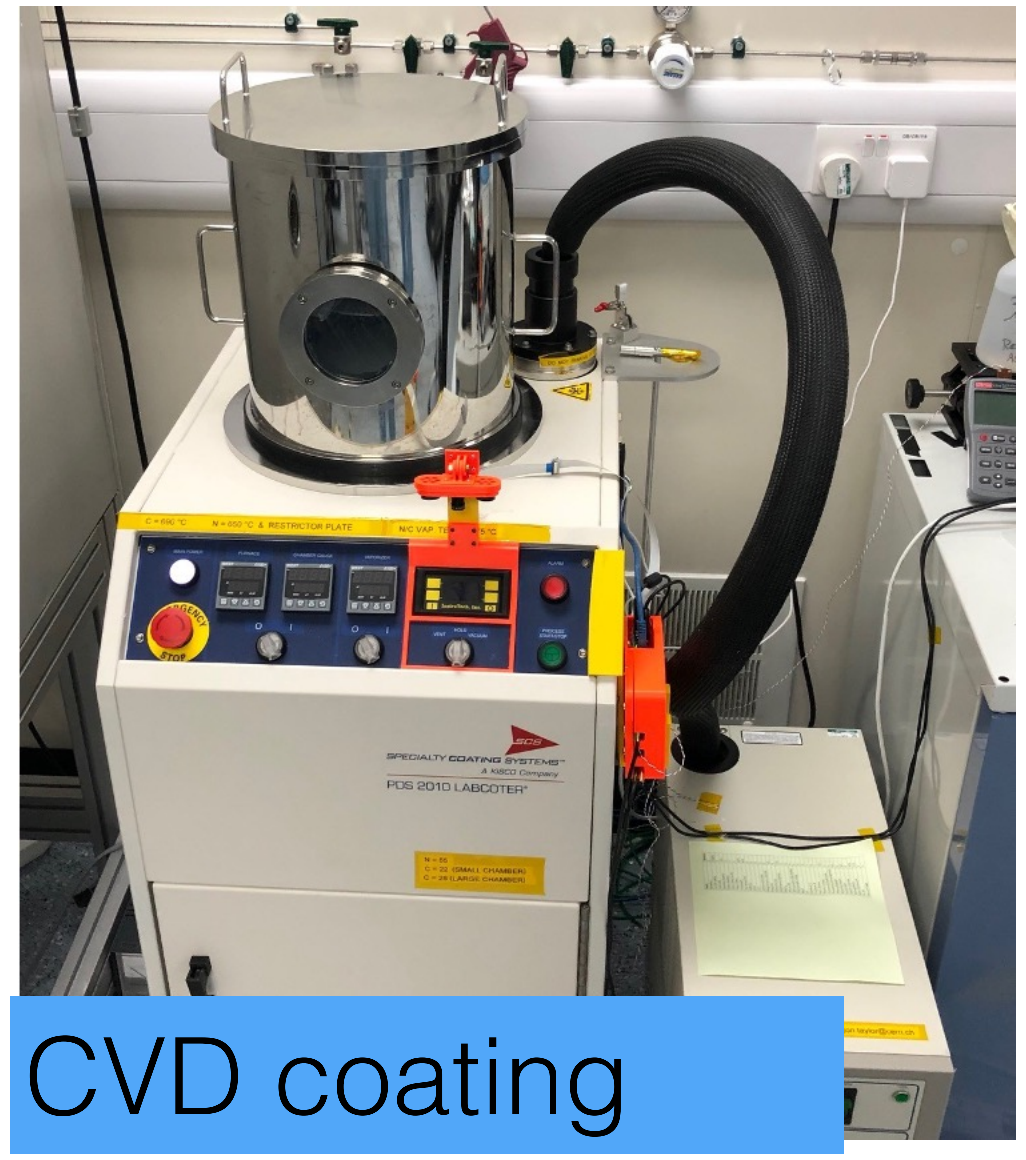
- DDMF is a shared departmental facility located on the ground floor of the Oliver Lodge
- AML funded by HEP group as a ‘SRF’

Major equipment









Summary

Questions?